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Recent Progress in Metallurgy.

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The opening address of the season 1905-6.

Once again it becomes my duty, as well as pleasure, to open the Autumn sessions of the Mining and Metallurgical Section of the Franklin Institute with an address to the members.

I have chosen for my subject a review of recent progress in metallurgy. This covers a wide field, and it will be impossible for me to do more than to touch very briefly upon the results of some of the original researches and their practical applications that have been made and published during the past twelve months.

One year ago it was my privilege to address you upon "The New Theory of Matter," and to present some novel views of the leaders of thought upon the nature of the ultimate particles

of matter out of which worlds are formed. I then said that the new theory was in an embryonic state, and should be accepted with caution, owing to its revolutionary character. Since that time new light has been thrown upon the matter and the views tentatively propounded have been endorsed and corroborated by many prominent men.

The indivisibility of the atom was, until very recently, regarded as an absolute fact; it was indeed a dictum of science; the corner-stone upon which chemistry and metallurgy rested in apparent security. It was believed that there was a score or more of so-called "elements," or primitive bodies, unresolvable into other substances, and built up of extremely minute particles called "atoms," which could not be further divided; these were the units corresponding, as we might say, to the bricks out of which a house is constructed.

Now, a marvelous change has come, due primarily to the discovery of radium and the study of radiations, leading to the growing belief that the atom is not indivisible, but is itself composed of hundreds, in some instances thousands, of smaller particles called "electrons." These electrons are regarded as points of negative electricity repelling each other and moving within circumscribed limits with enormous velocity, even approaching the speed of light.

To quote from a recent writer in *Engineering*, "J. J. Thomson imagines the atom to represent a globe charged with positive electricity, inside of which there are hundreds or thousands of corpuscles of negative electricity, revolving in regular orbits with great velocity. The forces called into play by the electrical inter-action would be very complicated. So far, J. J. Thomson has limited his detailed examination of the model atom to one containing about seventy corpuscles. If the movements of the corpuscles are to be persistent or stable, the corpuscles must revolve in definite orbits, and we thus arrive at an analogy between a complex modern atom and a planetary system. The stability of the atomic unit, regarded as a system, may last for millions of seconds. Finally we may expect it to break up, possibly by rejecting or expelling some of the corpuscles. Then another phase of stability will result. Infinite numbers of such communities would be conceivable, representing an infinite number of elements.* * * The laws which govern electric-

ity in motion indicate that an atom must lose energy by radiation, and must finally run down, as a clock does. In this sense Thomson has spoken of elements which may run for a million years. In radium and in other elements of very complex character, we probably witness this breaking up process and the spontaneous re-arrangement of the atoms which would constitute a transmutation of the elements. The minuteness of the corpuscles must be excessive."*

In my address given a year ago I referred to Lord Kelvin's calculation of the size of the ultimate particles of matter and to his illustration in which he imagined a drop of water magnified to the size of the earth, the molecules would then be of a size intermediate between that of a marble and a cricket ball. The molecule of water contains three atoms, or multiples of three—two atoms of hydrogen and one of oxygen. Prof. Darwin, the President of the British Association, suggested in a recent address on "Evolution," that the three atoms may revolve about one another in a manner analogous to that of a triple star. How much of the space occupied by the molecule is really occupied by the atoms we do not know. Prof. Darwin thinks the atom may bear to the molecule some relation like that of the molecule to the drop of water, and the corpuscles (electrons) may again stand in a similar relation to the atom.

Fascinating as these theoretical studies are, time will not permit us to linger longer in these realms of pure science, but before passing to the more practical phases of my subject I desire to call your attention to a leading article in the same issue of *Engineering* as that from which I have already quoted, entitled, "Steel as An Igneous Rock," of which I will give a brief synopsis.The days in which steel was practically regarded as an iron containing a certain proportion of carbon have gone by. We have learned that the other elements, always present in steel, exert a decided influence on all the properties of the iron; but we are still far from understanding the real nature of the purest steel.

While the inexperienced investigator may too readily imagine that he has struck at the root of the problem, Prof. Arnold

*Engineering, Vol. LXXX, No. 2071, Sep. 8, 1905.

declared in a discourse delivered before the British Association, August 31st, that he had to confess, after research extending over a quarter of a century, that the more he learned about steel the less he knew of its ultimate nature. Homogeneity is the great aim which most metallurgists have in view, but Prof. Arnold thinks that safety is to be found in want of symmetry, not in the visible structure, however, such as the microscope reveals, but in the molecular grouping, about which the microscope does not tell us anything. He regards steel as an igneous rock, more or less crystalline. There is, in his opinion, a certain analogy between granite and steel. The granite is built up of quartz, feldspar and mica; the steel of the constituents of ferrite, pearlite and cementite. In an unsaturated steel containing about 0.5 per cent. of carbon, the microscope allows us to distinguish patches of iron; the saturated steel with 0.9 per cent. of carbon, looks more homogeneously speckled with pearlite; in the supersaturated steel the iron carbide or cementite is seen to form cell-walls, and the cementation proceeds from the outside. Reference is made to several mysterious failures of steel and to micrographic and chemical tests, as well as physical tests of pieces of the metal, none of which offered satisfactory solution of the failures.

The explanation that failures often result from fatigue of the metal is characterised as only "a convenient term coined to mask our ignorance."

The tentative conclusions at which Prof. Arnold has arrived in explanation of certain strange fractures of engine, boiler, and structural steel is, that after the gross crystallization, discernible by the highest microscopical powers, has been completed on cooling, there set in, from a series of centers, molecular movements tending to the production of perfect mineral cleavage. This cleavage cannot easily be detected by the microscope, as steel is absolutely opaque to transmitted light. To avoid the development of cleavage planes the molecular structure of the steel should be asymmetrical. That crystallization proceeds from a series of centers can be demonstrated in many substances, and the decomposition and disintegration will start from the same centers.

I would say, in passing, that while steel is, of course, opaque

to transmitted light of ordinary kind, it is by no means opaque to the passage of X-rays or of radiations from radium.

About two years ago I exhibited in this hall some fine radiographs showing the permeability of steel and cast-iron to the X-rays and to the radium radiations. It will be remembered that in the case of cast-iron there was a decided difference in permeability or transparency to the rays between a specimen of ordinary gray cast-iron and a companion piece of the same iron of the same thickness that had been permanently expanded to a remarkable degree by repeated heating and cooling, whereby the particles of iron were permanently separated farther from each other, and the metal was rendered comparatively porous.

Reference was made by Prof. Arnold to an accident caused by failure of an end-plate of an old boiler, which had cracked completely across, in which the tests subsequently made of the metal could not account for the accident.

It has always seemed to me that there is one inherent defect in the prevailing practice of testing such metal, by cutting coupons from the plates after failure, in that they are tested at the ordinary temperature of the atmosphere, but the failure occurs usually while the metal is hot. It is, therefore, interesting to note that some elaborate tests of the "Elastic Properties of Steel at High Temperatures" have been recorded in a paper read before the Royal Society by Prof. Bertram Hopkinson and F. Rogers, of the University of Cambridge, printed in *Engineering* Sept. 8, 1905. In these experiments the elastic properties of steel and iron have been investigated at temperatures ranging up to 800 deg. C. (1452 deg. F.) It was found that "as the temperature rises the stress-strain relations undergo a remarkable change, which may be best expressed by saying that what is variously called the 'time-effect,' or *elastische nachwirkung*, or 'creeping' increases greatly with the temperature. Steel at high temperatures behaves like india-rubber or glass; if it is stressed for a time, and the stress removed, it does not at once recover; but after the immediate elastic recovery there is a slow contraction perceptible for many minutes. Such creeping can be detected at ordinary temperature, but at red heat attains a different order of magnitude,

becoming (in its total amount) a substantial fraction of the whole deformation."

Tests pieces 4 inches long and 0.2 inches in diameter between shoulders, having enlarged threaded ends screwed into two steel bars 10 inches long $1\frac{1}{8}$ inches diameter, were used, the whole being enclosed in an electric resistance furnace wound with three coils of nickel wire. The currents in these coils could be separately controlled, and in this way the temperature along the test piece could be maintained very approximately uniform. The temperatures were measured with three thermo-couples, placed one at each end and one at the middle of the test piece. Changes in length could be measured correctly to $\frac{1}{50000}$ inch by means of an extensometer. The furnace was supported separately, and the test-bar, with the attached extensometer was hung free within it. Tension up to $1\frac{1}{2}$ tons per square inch could be very rapidly applied or removed; the interior of the furnace was closed from the atmosphere by means of mercury locks, and the test piece was kept surrounded by an atmosphere of nitrogen, so as to avoid oxidation. Diagrams accompanying the paper show the results of a series of tests carried out on a steel bar at 750 deg. C. This bar was at no time heated much beyond that temperature. It was loaded with 85 pounds (about $1\frac{1}{4}$ tons per square inch) for one minute, then unloaded for two minutes, and so on, and the curve shows the resulting changes in length in terms of the time. Even at this low stress the metal flows fairly rapidly, and the overstraining has a considerable hardening effect, as is shown by the diminishing amount of permanent set produced by successive loadings. This hardening disappeared with rest, that is, if the bar were left unstressed at 750 deg. C. for a couple of hours after having been hardened by successive loadings, it was restored to its original soft state.

In respect to all the features mentioned the properties of the material differ only quantitatively from those of a cold bar but for one remarkable difference. This difference lies in the behavior of the bar after the removal of the load. The cold bar does not contract appreciably; there is the instantaneous elastic contraction, then it stops. The hot bar, on the other hand, goes on shortening for two minutes or more after the load is off, and the total shortening amounts to about one-third of the

instantaneous contraction, or one-quarter of the total contraction. This phenomenon is analogous to residual change in glass and other di-electrics, the stress corresponding to the electric force, and the strain to the electric displacement. The magnitude of this effect in steel may best be gauged by comparing it with other cases of the same kind, *i. e.*, with the slow recovery of the glass fibre after twisting; if such a fibre be twisted through a considerable angle for several hours, it will recover all but one-fiftieth of the twist within two or three seconds of the removal of the stress. The remaining slow "creep," amounting to one-fiftieth of the whole deformation, corresponds to the slow return of the steel.

In India-rubber, under certain circumstances, 10 per cent. of the stress and the strain disappears in time after the removal of the stress. But in steel at 600 deg. C. the proportion is about 15 per cent.

One effect of such a time-lag will be to cause dissipation of energy if the material be subjected to alternating stress, for it will lead to a difference of phase between the stress, and the strain; and the amount of the dissipation will depend upon the period of the oscillations.

The authors state that another effect of the "creeping" is to make the determination of Young's modulus a matter of some uncertainty, but it would take too much time to consider this phase of the subject here. For further particulars I refer to the original article, which I found exceedingly interesting.

A few months before the publication of these tests of the elastic properties of steel at high temperatures, Mr. R. A. Hadfield, President of the Iron and Steel Institute, read before that association his remarkable paper on the effect upon the mechanical and other properties of iron and its alloys produced by liquid air temperatures. This is a highly interesting and valuable contribution, giving the results of numerous costly and carefully-conducted original investigations. The author stated that as many iron alloys had shown anomalous results in their physical behavior at ordinary temperatures, it became desirable to ascertain the exact effect of very low temperatures upon such bodies, and accordingly he carried out a series of tests on standard iron and on iron alloyed with other elements. In the course of the inquiry no less than five hundred specimens were

examined. The bars experimented on were finished to .18 inch in diameter and were 2 inches long in the parallel part and 3.20 inches over all. The size of the specimens, therefore, did not vary greatly from that of the tests made by Prof. Hopkinson on the elastic properties of steel at high temperatures. The two investigations had no relation with each other, but it seems appropriate that they should follow one another as a corollary.

The first specimen examined by Mr. Hadfield was of Swedish charcoal iron, approaching pure iron in its composition. The analysis gave Fe. 99.82, C. 0.045.% Si. 0.07% S. 0.005% P. 0.004% Mn. trace.

This iron, after careful annealing, gave twenty tons per square inch tenacity, and 20 per cent. elongation at normal temperature; after cooling in liquid air the tenacity rose to thirty-eight tons, with substantially no elongation. Another specimen, after being quenched at 950 deg. C. and and again at 600 deg. C. in water, showed similar results in liquid air. Two other specimens in the unannealed condition, and one after special heat treatment, showed similar properties. Specimens immersed in liquid air, and allowed to return to the normal temperature before testing, had almost exactly the same tenacity and elongation as before cooling, thus showing that the brittleness was entirely a function of temperature. In addition to tests made on specimens of steel with various amounts of carbon, alloys of iron and chromium, tungsten, silicon, aluminum and copper were tested. Mr. Hadfield's conclusions are as follows:

"Practically at this low temperature (—182 deg. Cent.) pure iron has its tenacity more than doubled; its well-known ductility falls very low; its magnetic properties remain almost the same as at higher temperatures.

This represents the general behavior of all the alloys, excepting those containing nickel, which are less affected, as regards loss of ductility, whilst an iron alloy containing 5 per cent. of manganese and 25 per cent. of nickel has its extraordinary ductility, about 60 per cent., still further increased, and the tenacity also largely increased. Manganese steel has its ductility lowered; but its non-magnetic properties remain apparently unaffected. The whole of the results combine to offer a most

interesting field for observation of the physical properties of iron, both at ordinary and at liquid air temperatures."

Related more or less closely to these investigations we may properly refer briefly to the great advance that has been made in knowledge of the influence of heat treatment on the physical properties of steel, and of the practical use that is being made of these observations. We now know that the proper heat treatment of steel rails before, during and after rolling is of vital importance in the production of good rails. Good material may be spoiled by bad treatment at a critical moment of the rolling. The microscope has found a field of great usefulness in enabling the chemist to determine whether a failure is due to faulty heat treatment or to other causes.

Passing now to the consideration of recent advances of a practical nature in metallurgy, it seems to me that one of the most interesting developments within the year has been shown in the paper of Mr. Jas. A. Gayley on the application of dry air in blast furnace practice. So much has been written upon this subject since the original paper appeared in print that it would be superfluous for me to do more than allude to it here. While it was by no means a new observation that the amount of moisture in the atmosphere exerted a decided influence on the product of blast furnaces, no one had apparently anticipated the gain in economy which Mr. Gayley showed by his method of freeing the air of its moisture before passing into the furnace. So remarkable are these results that various theories have been advanced to account for them of more or less abstruse nature. It remains still to be seen whether the method will be found sufficiently advantageous and economical to warrant its universal adoption. In these days of scientific progress in the production of pig-iron in enormous furnaces, new methods meet with prompt encouragement from furnace proprietors and it is to be hoped that Mr. Gayley's ingenious plan will prove thoroughly successful.*

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*The September record of two Isabella furnaces at Pittsburgh, one of which is operated on the Gayley dry-air blast and the other on ordinary blast, is interesting, says *The Iron Age*. No. 1 furnace, with the Gayley refrigerating plant, made a ton of iron with 1939 pounds of coke, while No. 3, using ordinary blast, required 2339 pounds, a lowering of the coke consumption in favor of the Gayley dry-air blast of 400 pounds per ton of iron.

GOLDSCHMIDT'S SYSTEM OF ALUMINO-THERMICS.

During the year we have had a fine demonstration in this hall of various practical applications of Dr. Goldschmidt's ingenious and simple process in the production and utilization of very high temperatures by means of mixtures of aluminum with a metallic oxide, such as oxide of iron, and we also have the report of the sub-committee on Science and Arts on the invention, which unanimously recommended the award of the Elliott Cresson gold medal, the highest in the gift of the Institute, to Dr. Hans Goldschmidt, of Essen, Germany, for his discoveries in "Alumino-Thermics." This award was confirmed by the Institute.

In addition to the welding operations exhibited here with marked success, the process is adapted to and is practically applied to the production of rare metals free from carbon, which are finding immediate use in the metallurgical arts, thus: Chromium 99% pure, is now made by this process for steel alloys, produced either in the crucible or in the open hearth; also Molybdenum 99% pure, and free from iron. Manganese of equal purity is similarly made. Ferro-Titanium containing as much as 25% of the latter metal, and various other alloys, such as Manganese-Copper, Manganese-Tin, Manganese-Zinc, &c., are furnished commercially, made by this process. It is interesting to remember that pioneer work in this field was conducted years ago by two distinguished members of the Franklin Institute, Drs. Wahl and Greene, who were the first to employ metallic aluminum as a reducing agent for the production of the difficultly reducible metals, and who placed carbonless manganese and chromium on the market in commercial quantities a number of years before the Goldschmidt process was announced.

Calcium can now be obtained commercially. The usual impurities are Silicon 0.2 to 0.5%, aluminum 0.2 to 0.3% together with traces of iron. The specific gravity of pure calcium is 1.52. Calcium has been found to be sufficiently tenacious to be

No. 1 furnace made 413 tons of iron per day, as compared with 362 tons for No. 3, a gain of 51 tons per day. It should also be noted that No. 1 was running on Bessemer pig and No. 3 on basic, the former carrying 0.5 per cent of silicon more, so that iron made in No. 1 should realy have used more fuel.

drawn into wire as fine as 0.5 millimeter in diameter, and these wires have a specific electric conductivity of about 16 per cent of silver.

MAGNETIC NON-IRON ALLOYS.

Prof. J. H. Fleming and R. A. Hadfield in a recent Royal Society paper, give the latest results of their work of investigation of the magnetic qualities of some alloys not containing iron. The alloy experimented with was composed of manganese, 22.42%; copper, 60.49%; aluminum, 11.65%; carbon, 1.5%; silicon, 0.37%; iron, 0.21%. About 2 or 3 per cent. of slag was intermingled, mostly consisting of manganese and silicon oxides, with slight traces of metals other than the above mentioned. The conclusions of the paper are as follows:

The above alloy exhibits magnetic properties which are identical with those of a feebly ferro-magnetic material.

The magnetization curve is of the same general form as that of a ferro-magnetic metal, such as cast-iron, and indicates that with a sufficient force a state of magnetic saturation would most probably be attained.

The alloy exhibits the phenomenon of magnetic histeresis. It requires work to reverse the magnetization of the material and to carry it through a magnetic cycle.

The material has a maximum permeability of 28 to 30, which is not greatly inferior to that of the values reached for cobalt or a low grade of cast-iron for small magnetic forces, and occupies a position intermediate between the permeability of the ferro-magnetic and the merely paramagnetic bodies, such as liquid oxygen and ferric chloride.

The material exhibits, therefore, the phenomenon of magnetic retentivity and coercivity. It is not merely magnetic, but can be permanently magnetized.

A further conclusion is that the magnetic properties of this alloy must be based on a certain similarity of molecular structure with the familiar ferro-magnetic metals. The hypothesis which best fits the facts of ferro-magnetism is that materials such as iron, nickel and cobalt, are composed of molecular groups, which are permanently magnetic, and that the process of producing or changing the evident magnetization of a mass of these metals consists in arranging or disturbing the positions

of these molecular magnets. Since, then, we have in this alloy an instance of fairly strong ferro-magnetism produced by an admixture of metals possessing in themselves separately no such property, it follows that ferro-magnetism *per se* is not a property of the chemical atom, but of certain molecular groupings. The importance of this fact cannot be easily overstated. It shows us that in spite of the fact that ferro-magnetism has been hitherto regarded as the peculiar characteristic of certain chemical elements—iron, nickel and cobalt—it may, in fact, depend essentially on molecular grouping composed of a comparatively large number of molecules, and, hence, it may be possible to construct alloys which are as magnetic, or even more magnetic, than iron itself.

Commenting on the paper, the London *Electrician* says that the discovery of the secret of the molecular grouping referred to would be of immense importance, as it will lay bare the whole mystery of magnetism, and might make possible the manufacture of a material even more magnetic than iron itself.*

BY-PRODUCTS.

The utilization of so-called "waste products" is daily becoming more and more important, and in some industries the recovery of by-products, which were formerly thrown away, proves actually more profitable to-day than did the original operation in former times. Among the inventions aiming to recover waste products most deserving of notice here is "Clamer's Method of Eliminating Metals from Mixtures of Metals." This process was investigated by the Committee of Science and Arts and the Elliott Cresson medal was awarded to Mr. G. H. Clamer for his invention, which has been patented and pushed into successful operation on a large scale in this city and elsewhere.

The report of the sub-committee states that the invention is a new method of utilizing brass scrap, and producing therefrom a merchantable bronze, or a material which can be used in the manufacture of merchantable bronze. If it is attempted to remelt scrap brass for use again the iron which unavoidably

*Electrical World.

contaminates it, together with the lead and tin of the solder and oxide of zinc produced during the melting, make a remelted metal which is practically worthless. The Clamer process eliminates the oxidizable mixtures in an ingenious way by so regulating the ingredients of a charge of scrap and waste products for the furnace, based upon analysis of the scrap, that there shall be sufficient quantities of oxides of copper, lead or tin to oxidize a certain quantity of zinc and iron. Not only are the impurities removed by these reactions, but the purifying materials on performing their function, and by reason of their reaction, are themselves reduced to the metallic state and contribute copper, lead and tin to the bath. For every 65 parts of zinc or 56 parts of iron oxidized, there would be furnished 127 parts of copper or 207 parts of lead, or 118 parts of tin, or aliquot proportions of these, according to the proportions of oxides of copper, lead or tin used. This fact is economically of great importance, because, the oxides of copper, lead and tin are found commercially in large quantities as waste products, called copper scale, and lead and tin dross, or skimmings, and are purchasable at a comparatively low price. By utilizing these waste products as active agents to eliminate impurities from another waste product, the deleterious materials (zinc, iron, oxygen) are all eliminated by mutual reaction, and only the useful combination, copper, tin and lead, remains.

The practical operations are conducted on the hearth of a reverboratory furnace, lined with magnesite brick, and are simply and easily managed.

FERRO-SILICON IN THE FOUNDRY.

Among the comparatively new metallurgical products for which I think an increased use will be found, is an exceedingly rich ferro-silicon alloy, containing from 50 to 80 per cent. of silicon.

Ferro-silicon containing from 12 to 20 per cent. of silicon has been a commercial product for a long time, but the new very rich silicon alloy possesses distinctively valuable properties which I have discovered in the course of some extended investigations not heretofore published.

One of the difficult problems of foundry practice where mis-

cellaneous castings are made is to economically obtain from one melting in a cupola different grades of iron suitable for different classes of castings requiring perhaps very different qualities of metal. Thus, the articles may range from castings of many tons weight, usually of thick section, requiring strong iron of close grained texture, often having high chilling properties, to small objects of a pound or so in weight, frequently of thin sections, which require to be machined, and therefore must be of softer metal having little or no tendency to chill.

As silicon is practically the *governor* that determines the degree of hardness of cast-iron, the value of a simple process that will enable the intelligent founder to control the proportion of silicon in any individual ladle of molten iron drawn from a cupola is apparent, especially in foundries where miscellaneous castings, ranging in size from small pulleys weighing a few pounds, with rims one-quarter inch thick, up to anvil blocks, bed plates for various machines, hydraulic cylinders and the like, sometimes weighing many tons and of varying thickness, up to twelve inches or more, as is the daily practice in the foundry with which I have been connected for many years. The silicon in such castings ranges usually from 2½ per cent. to less than 1 per cent., and the customary method of operation is to group all the small work so that it will be cast at the beginning of the heat, followed by a medium grade of iron suitable for miscellaneous castings of medium weight and thickness, this again followed by large and heavy work requiring strong iron of close-grained texture, low in silicon, and having high chilling properties.

By arranging the work so as to have a certain number of castings to serve as "buffers," *i. e.*, to take iron that is intermediate between the different grades charged in the furnace, this method has proved very satisfactory, and now it can, I think, be supplemented by *altering at will the silicon in any individual ladle*, to a nicety that is truly surprising.

In this way it is possible and practicable to use a lower grade of iron in the general mixture than could otherwise be done. At present the operation is confined to treating ladles of iron for the lightest class of work, requiring the softest grade of iron, so as to permit of machining at high rates of speed; but, when the price of ferro-silicon, containing 50 per cent. and up-

wards of silicon, shall fall, as I have little doubt it will, to a more reasonable figure, the use of it in the way I have here indicated will become general. I am led to make this assertion from experience based on my original investigations with ferro-manganese (80 per cent. manganese) in car-wheel iron in the year 1886. The cost of ferro-manganese was then more per ton than the present price of ferro-silicon (50 per cent silicon). To-day it is less than half that price, and the use of ferro-manganese for certain purposes, especially in chilled cast-iron car wheels, in the way I described in my lecture on "Cast-Iron," printed in *The Journal of the Franklin Institute*, March, 1888, and in practically the same proportions, has long since become well established. It has been stated in print by a recent writer that when the Pennsylvania Railroad authorities adopted the "thermal test" for car wheels, the wheels of nearly all the makers failed to stand this test, until a small quantity of ferro-manganese was added in the ladle just before pouring. This gave the metal additional elasticity that enabled the wheel to resist the severe strains caused by heating the rim suddenly in the thermal test.

As the result of a large number of experiments made with test bars of foundry iron treated with small quantities of ferro-silicon (50 per cent. Si.), say one-quarter to one per cent., I have found an average gain in strength of about 15 per cent, and a somewhat larger average gain in ductility, or bending quality, accompanied by a marked increase in softness of the metal.

I have here a number of test specimens of the treated and untreated iron; those which show most plainly the softening effect are the wedge-shaped castings six inches long, four inches wide, one-quarter inch thick, tapering to a feather-edge, cast of medium grade foundry iron and split down the middle to show the grain. In some of these the untreated sample is white all through, in others it is white at the thinnest portion only, but in all the specimens cast from the same ladles after treatment with from one-quarter to one per cent. of ferro-silicon, the casting are gray throughout and soft enough to drill or file.

The silicon in the untreated samples ranges from 1.7 to 2.25 per cent, and in the treated specimens from 2 to 2.75 per cent. I find that the addition of even so little as one pound of this alloy, in a powdered form, in a ladle containing

200 pounds of foundry iron produces a remarkable effect, not only as a softener, but what is more surprising and equally valuable, it is invariably accompanied by an increase in strength and resilience, or ductility, of the metal, although we have added actually a little less than 0.25 per cent. of silicon to the iron. By adding four times this amount of the alloy to a very hard iron mixture of iron in a ladle which ran quite white when cast in thin sections, and was, therefore, entirely unsuitable for small castings requiring to be machined, I have found that I can produce a soft gray metal of good strength and ductility with low shrinkage, suitable for casting pulleys and other light work.

I am, of course, aware that it is not new to use brands of silvery iron, known as "softeners," containing five, ten, or perhaps even fifteen per cent. of silicon, in the manufacture of iron castings, but so far as my experience goes in commercial practice, covering thirty years, the addition has been made in the cupola itself, which results in either what may be considered as a fixed product, or, if varied during the heat, in a product which is indeterminate, so as not to be predictable at at a given moment of tapping.

I believe, therefore, that it is a new discovery to note the immediate diffusibility of the high-grade ferro-silicon when added to a relatively small quantity of melted cupola iron which has been withdrawn from the source of heat supply, and its capacity, when thus diffused, to produce definitely controllable results in the physical characteristics which are essential in different grades of castings.

The cost of the small addition of high-grade ferro-silicon in the ladle, even at the present price of the powdered alloy (about four cents per pound), is trifling, and is far more than counterbalanced by the fact that lower grades of pig-iron may be used in the furnace, besides the practical value of being thus able to absolutely control the product and to vary the character of the metal in regard to softness, or machining quality, at the same time increasing the strength and ductitily of individual ladles of iron drawn from one common source.

ELECTRO-METALLURGY.

Wonderful progress is being made wherever cheap power from water-falls is obtainable in all branches of electro-metallurgy. In Europe they are actually making steel at various places in electric furnaces in a commercial way. A commission of experts was appointed by the Canadian Government to visit Europe and study these methods, and it is now reported by Vice Consul General Gorman, of Montreal, that the Dominion Government has appropriated $15,000 for making experiments with the electric process of smelting ores and manufacturing steel at Sault Ste. Marie, and the Consolidated Lake Superior Co. will furnish a building and dynamo capable of supplying 400 electric horse power for four months free of charge. All kinds of ores will be experimented with, and important results are expected to be obtained.

Great possibilities for Canada underlie the inauguration of a cheaper process for manufacturing pig iron and steel than is now in use. Ontario is dotted with ore bodies, the development of which is at present prevented by lack of cheap fuel. There is coal in the eastern and western parts of Canada, but the cost of conveying it to points where coke is needed for smelting purposes is prohibitive. On the other hand, there are a great many water powers throughout the provinces of Quebec and Ontario where electricity can be developed and utilized. If the electric system proves to be commercially feasible Canada is looking for the inflow of a large amount of capital and considerable mining development.

The Kjellin electric steel furnace at Gysinge, near Stockholm, Sweden, has been in operation since 1899, and it is claimed the process will bear comparison with the crucible and open-hearth furnaces in production on a large scale. The record shows that about 5,000 kilos of ingots are cast in twenty-four hours, or a little over 12,000 pounds. This furnace is chiefly employed in the regular production of tool-steel. The specialties manufactured at the Gysinge works are drills and chisels, forged stamping tools, steel forgings and forged steel for gun barrels, magnets, etc. The special qualities of this steel are its great elasticity, absolute homogeneity, softness and the high proportion of carbon, together with its excellent magnetic properties.

The magnitude of the metallurgical industries of this country is truly amazing, but time will not permit me to give you statistics except in a very limited way.

It is stated that we are turning out 41 per cent. of all the steel made in the world to-day, and still we are not making enough for home consumption. The imports of iron and steel for the last fiscal year exceeded $23,000,000.*

Even in secondary or subsidary operations, which do not attract general attention, we hold a leading position among the civilized nations. Let us consider for a moment the case of the galvanizing and tinning processes, and we will find amazing figures of tonnage.

In a recent article by Chas. F. Burgess in the *Electro-Chemical and Metallurgical Industry* on "The Action of Acids on Iron and the Use of the Acid Pickle," the following interesting statement appears: "Pickling constitutes an essential step in the well-known galvanizing process. Prior to immersing the sheet metal in the molten zinc it must be freed from scale and other oxides, and this is most satisfactorily accomplished by the use of the acid dip. To show something of the magnitude of this operation alone it may be estimated that since 60,000 tons of zinc per annum are used in this country for galvanizing, the area of surface which is thus protected is approximately equivalent to seventy square miles, or 40,000 acres. The area which must be pickled in the manufacture of wire and sheet metal probably largely exceeds even this. Statistics show that about 1,500,000 tons of iron and steel wire were produced in 1903. Such an amount of iron in the form of wire posseses over 100 square miles of area, and since the process of pickling must be repeated several times during the operation of drawing, the pickled area is unquestionably larger than this amount. From figures taken from the United States Census Report for 1900 about 20,000,000 pounds of tin were used for the production of tinned sheets, and this again represents a second area of about

*The production of pig iron in the United States, according to the annual statistical report of the American Iron and Steel Association for the year 1904, was 16,497,033 gross tons. The latest estimates indicate that the furnaces are now making pig-iron at the rate of nearly 30,000,000 tons a year. Ten years ago the production was considerably less than half this amount.

140 square miles which must be pickled, not once, but twice."

I call attention to this statement in order to show the magnitude of galvanizing and tinning operations in the United States.

A comparatively new method of pickling iron castings to remove sand is to immerse them in a pickling bath containing hydrofluoric acid and water. Hydrofluoric acid dissolves sand while sulphuric acid dissolves the iron and does not affect the sand, merely loosening it. Experiments which I made some years ago in pickling cast-iron test bars in both acids showed that the sulphuric acid pickle caused a loss in strength and ductility of the bars averaging nearly ten per cent., while bars pickled in hydrofluoric acid were not appreciably weakened thereby.

THE METAL OF THE FUTURE.

A recent dispatch from Washington to *The Iron Age* says: "The production of aluminum in the United States has increased nearly ten fold in as many years, according to the annual report of the U. S. Geological Survey for 1904, which has just been completed. Two reasons explain this phenomenal growth—economic production, which has initiated low prices, and increased consumption, especially in the electrical industry. The output of 1904 was 8,600,000 pounds as compared with 7,500,000 pounds in 1903. When it is remembered that the industry dates its beginning from 1883, in which year the production was 83 pounds, its rapid development will be appreciated. It was not until 1891 that the output reached 100,000 pounds, but from that date the output has been phenomenal.

Aside from the electrical industry, in which aluminum is gaining favor as a substitute for copper conductors for the electric transmission of light and power, there has been expansion in other directions. The steel industry has become an important consumer of aluminum. Usually from two to five ounces of aluminum are employed per ton of open-hearth steel made, and from six to eight ounces for Bessemer steel. If every ton of steel manufactured in the United States in 1904 had been subjected to this treatment there would have been about 5,000,000 pounds of aluminum consumed.

Among other uses of aluminum may be mentioned parts of looms and other vibrating or moving machines, household and

military utensils, lithographic plates, alloys with copper, zinc and other metals, motor-car fittings, chemical vessels, &c."

A practical method for plating aluminum on iron would be a valuable discovery. In this connection I cannot help alluding to the fraud that was perpetrated upon the City of Philadelphia some years ago, when thousands of dollars were paid ostensibly for plating the iron work of the great tower on the City Hall with aluminum. It was claimed that this light-gray colored metal was heavily plated on all the iron work and that it would retain this color, closely resembling the stone base of the tower indefinitely without further attention. The black appearance of the iron of the tower, and its serious injury by reason of oxidation, is a sufficient proof, if such were needed, of the falsity of these statements. I believe I am correct in saying that there was no known method by which the iron could have been protected by a galvanic coating of aluminum at that time, and I doubt if it would be possible even at this day. Aluminum being a highly electro-positive metal does not lend itself to the process of electro-plating.

CONCLUSION.

I have endeavored to give you as brief a survey as possible of the field covered by metallurgical industries and of the progress made therein since my last address a year ago.

I am conscious that I have merely touched upon a few themes, and have neglected many others of perhaps equal importance. Yet I have occupied more of your time than I intended to do. I hope, however, that I have not wearied you, and I wish to thank you for your attention, and to congratulate you upon the prospects before you in the large number of important papers which the program announces for the winter course, all of them by men of recognized ability in their profession.

ELECTRICAL SECTION.

(Stated Meeting, held Thursday, October 12, 1905.)

Electrolytic Copper.

By Lawrence Addicks.

[The author here discusses the subject of the electrolytic refining of copper, especially from the point of view of the multiple system of refining.—The Editor.]

The advent of the dynamo made electrolytic copper at once possible and necessary. The consumption of copper pursuant upon the generation and transmission of electric power in quantities never dreamed of in the days of primary batteries, has many times exceeded the output obtainable from the few sources of the native metal which will yield a product of satisfactory conductivity without electrolytic treatment.

The fact that certain mines in the region of the Great Lakes yield a mineral so free from objectionable impurities that a high grade copper is obtainable directly by a simple furnace scorification, early gave Lake copper a premium in the market that electrolytic competition even yet has not entirely wiped out. For almost all purposes there should be no hesitation whatever to-day in specifying electrolytic copper. In conductivity it is superior to nearly all brands of Lake, and in mechanical properties it leaves little to be desired. There are a few classes of work in which the metal is subjected to very severe punishment, such as in the making of cartridges, where Lake seems to stand up better than electrolytic, although even here it is a question how much to allow for the trade prejudices of the older generation of mill foremen who clung so tenaciously to the perplexing system of wire gauges of but a few years past. Any such advantage in Lake copper must be attributed to the fact that it is not so clean as electrolytic. A small quantity of arsenic, for example, while exceedingly detrimental to the conductivity, will appreciably improve the mechanical properties of

copper. At one time arsenic was considered necessary in English specifications for firebox copper. Each year a greater proportion of the world's output is electrolytically refined, and it seems probable that before long there will be but two grades of copper on the market—high conductivity copper, which will include electrolytic and picked brands of Lake, and casting copper, covering all material which will not pass a conductivity requirement of 98 per cent. annealed.

The ideal electrolyte for refining copper would be one chemically inert as a solvent but capable of electrochemically dissolving copper, and of zero specific resistance. These conditions are most nearly met by an acidulated sulphate solution, and this has the additional commercial advantage of employing one of the cheapest of chemicals, sulphuric acid. A sufficiently high percentage of sulphuric acid may be carried to make the specific resistance very low. There is a slight redissolving of the cathode copper, but not in serious amount. Gold is untouched and silver practically so. It is customary to carry a minute percentage of some soluble chloride as a constituent of the electrolyte which would throw down as chloride any silver which might be dissolved and also tend to slime antimony as oxychloride. Some claim that smoother cathodes result from the presence of chlorine. While the actual benefits from this ingredient are open to question, it certainly does no harm, and the refiner is often morally sustained by its presence.

In American refineries high grade anodes are universally used. Usual compositions are:

Copper	98 to 99.5 per cent.
Silver	0 to 300 ozs. per ton.
Gold	0 to 40 ozs. per ton.
Arsenic	0 to 2 per cent.

Small amounts of antimony, bismuth, iron, nickel, sulphur, selenium, tellurium and silicon.

Impurities with soluble sulphates go entirely into solution and grow cumulatively. Selenium and tellurium and the precious metals go entirely into the slimes. We have therefore a triple separation. The usual products are only copper at the cathode, silver and gold from the slimes, and sometimes copper and nickel sulphates from the electrolyte. Selenium and tellurium, especially the

latter, are easily recoverable from the slimes, were there sufficient market. Tellurium is an element almost without use in the arts. Small amounts are used in medicine, but the output of one of our copper refineries for one day would stock a large chemical supply house with tellurium enough to last a year. Arsenic, antimony and bismuth go partly into solution, partly into the slime, depending on the nature of the form of combination in which they exist in the anode and various secondary reactions taking place in the electrolyte.

Arsenic is the most difficult impurity with which to deal. If much is present in the anode, say over one per cent., it rapidly grows in the solution and necessitates a large expenditure for purifying to hold it down. With small quantities it seems to slime more rapidly and no purifying at all is necessary. With other conditions properly cared for, satisfactory cathodes can be produced in an electrolyte running two per cent. arsenic, though this is considerably above the customary figure.

The purification of solutions is almost always done by working up a certain quantity regularly into bluestone and adding fresh acid to the electrolyte. If the purification requirement is heavy the bluestone department becomes disproportionately large, and consequently copper running high in arsenic is most unwelcome. Antimony and bismuth are seldom present in sufficient quantity to cause trouble. Various chemical methods of purification have been tried with the object of regenerating the electrolyte and returning it to the circulation, but there are few substances that will precipitate arsenic in an acid solution, and further the action of such reagents does not seem reliable, probably due to differences in form of arsenic compounds present at different times. For example, the writer has boiled electrolytes running high in arsenic with metastannic acid* and obtained a remarkable cleansing action and upon other trials, found hardly any precipitation.

The insoluble anode slime from which the gold and silver are recovered is very variable in composition, as might be expected, depending on the grade of material being handled. It is chiefly metallic in nature and a common composition would be as follows:

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*U. S. Pat., No.———, F. B. Badt.

Silver	40 per cent.
Gold	2 per cent.
Copper	25 per cent.
Selenium and Tellurium	5 per cent.
Arsenic and Antimony	10 per cent.
Lead, Silica, Sulphuric Acid, etc.	18 per cent.
	100 per cent.

The presence of so much copper in the slime is objectionable in the silver refinery process and must be removed before cupelling the dried slimes to avoid making very rich slags. The other impurities give but little trouble, except possibly tellurium, which requires prolonged furnace treatment to burn it off. The copper is present in very finely divided form, as is shown by experiments in fine screening to reduce the copper contents. Almost all of the copper which will pass a 40-mesh wire screen will also pass a 200-mesh. This would indicate that the coarser screen removes the fine crystals that have dropped from the cathodes and that the remainder is in the form of a chemical cement. Wohlwill's experiments* indicate that this is due to the formation of some cuprous sulphate at the anode with subsequent oxidation to cupric sulphate and the liberation of metallic copper.

$$2Cu' = Cu'' + Cu$$

The amount of cuprous sulphate formed is a problem in chemical equilibrium dependent upon many factors. The copper dust is usually removed by leaching it out in hot concentrated sulphuric acid, taking care not to carry the action too far, as this would result in dissolving some of the silver. If a more rapid reaction is made use of, such as that with ferric or silver sulphates, the copper is dissolved almost immediately, owing to the enormous surface exposed.

The cathode copper is exceedingly pure, usually running about 99.93 per cent. copper, with hydrogen as the chief impurity. Objectionable cathode impurities are of two classes—those which depress the electrical conductivity and those which make the metal brittle. Arsenic and antimony represent the first class; tellurium and lead the second. Good cathode copper should show but a few thousandths of a per cent. of arsenic and antimony. The writer's experiments have indicated that

*Zeitschrift für Elektrochemie, April 23, 1903, p. 311, *et seq.*

it takes but 0.0013 per cent. of arsenic or 0.0071 per cent. of antimony to lower the conductivity one per cent. Any conductivity troubles in electrolytic copper can almost invariably be traced the presence of undue amounts of one or both of these elements. Impurities of the brittle-making class are very rarely met with, and if present are due to mechanical contamination of the cathode, either in the bath or in the subsequent furnace treatment. A third class of cathode impurity concerns the refiner, comprising silver and gold. Cathodes usually show from one-tenth to one ounce of silver and a trace of gold.

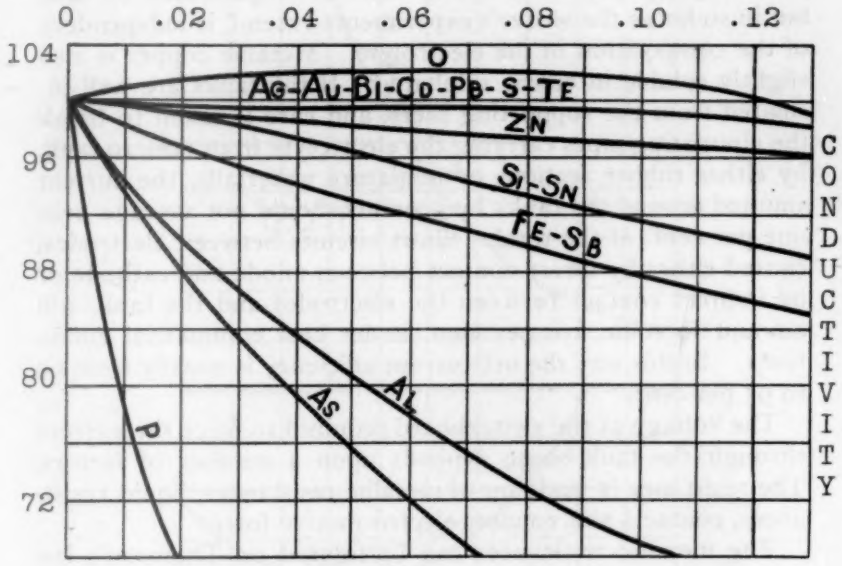

Fig. 1

This seems to be due entirely to the mechanical fouling of the cathode by particles of anode slime. In fact, it is a question if most of the arsenic and antimony found in the cathodes does not have a similar origin. The slime is very finely divided and the continual circulation of the electrolyte necessary to prevent polarization maintains a very slight turbidity. These particles are probably electrostatically attracted to the cathode. Fig. 1 shows in a general way the effect of various impurities on the electrical conductivity of copper.

The output of a refining tank depends upon the total current

passing through it, the number of electrodes in series, the time the current flows and the electrochemical equivalent. In the present case the theoretical amount per ampere day per pair of electrodes in series is almost precisely an avoirdupois ounce. The amount actually deposited is always less than this, due to chemical solution of the cathode, grounds and short circuits between electrodes. The redissolving of the cathodes will amount in practice to 0.5 to 1.0 per cent. of the amount deposited. This action is chiefly at the surface of the bath. In the presence of oxygen, copper is slowly oxidized to cupric sulphate by sulphuric acid.* The reaction is quickened by heat but in so far as the writer's experiments extend, is independent of the composition of the electrolyte. Metallic copper is also slightly soluble in cupric sulphate.† If the tanks are well insulated from the supporting piers, and care is taken to break the circulating pipes carrying the electrolyte from tank to tank, by either rubber sections or miniature waterfalls, the current shunted around the tanks by grounds should not average over one per cent. of the total. Short circuits between electrodes, caused either by direct contact between anode and cathode or by indirect contact between the electrodes and the tank, will amount to some five per cent. under best commercial conditions. In this way the net current efficiency is usually from 90 to 95 per cent.

The voltage at the switchboard required to force the current through the tank-house depends upon a number of factors. The resistance is made up of metallic resistances, liquid resistances, contacts and counter-electro-motive-force.

The metallic resistances can be figured on Thomson's law that the cost of power lost should equal the interest on the investment in copper. As the continuous operation gives a load factor of 100 per cent. the rule can be applied without the usual allowances. As regards the investment, the copper can be considered as so much extra metal tied up in the process. Any density under 1000 amperes per square inch will run cool enough.

The liquid resistance of the electrolyte is largely influenced

*Electrochemist and Metallurgist, April, 1902, p. 103.

†Zeitschrift für Elektrochemie, April 23, 1903, p. 311, *et seq.*

by its chemical composition. Fig. 2 shows the approximate specific resistances of electrolytes carrying varying amounts of copper and free acid. The conductivity of an electrolyte depends upon the number of ions present, the speed of migration and the charge of electricity each carries. The charge carried

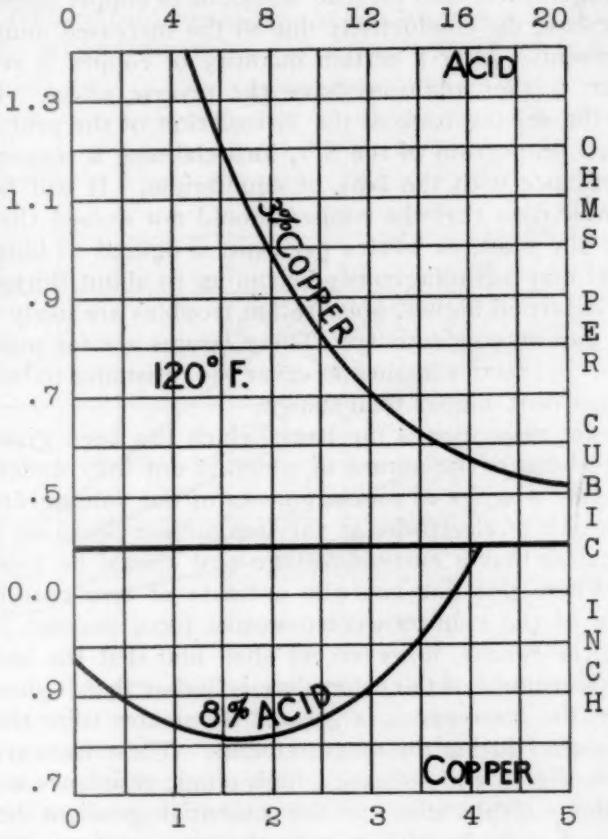

Fig. 2

is a constant for the various compositions as the valency does not change. The ions concerned are copper, hydrogen and sulphion. Hydrogen is much the swiftest of these and hence the effect of the free acid present in lowering the resistance. The number of ions present depends upon the concentration

and the degree of dissociation. In this case we have a mixture of two electrolytes with a common anion, SO_4, and the proportion of one present controls the degree of dissociation of the other. This is shown in the curve giving the effect of varying the copper contents of the solution. Starting with a fixed percentage of free acid present, additions of copper sulphate at first increase the conductivity due to the increased number of ions present. After a certain quantity of copper is reached, however, further additions have the reverse effect. This is due to the driving back of the dissociation of the acid by the increased proportion of the SO_4 ions claiming a copper mate in accordance with the laws of equilibrium. It will be seen from these data that the copper should not exceed three per cent. at the most, or twelve per cent. if figured as bluestone. The acid may advantageously be run up to about thirteen per cent. If carried higher, polarization troubles are likely to offset the gain in conductivity. These figures are for pure electrolytes. In practice impurities cause the resistance to be ten to fifteen per cent. higher than shown.

Transfer resistance is the name which has been given to a liquid resistance, the nature of which is not fully understood. If we make a series of measurements of the voltage drop between a pair of electrodes at varying current densities, Ohm's law requires that a current-voltage plot should be a straight line. Where this line cuts the ordinate of zero current is a measure of the counter-electro-motive force present. If we analyze the results, however, we shall find that the indicated specific resistance of the electrolyte is higher that it should be, and that the discrepancy is greater the nearer were the electrodes spaced during the measurements. These facts are illustrated in Fig. 3, and indicate a high ohmic resistance near the electrodes. Exploration of the potential gradient between anode and cathode with a potentiometer confirms this and shows that it exists at both electrodes.* The most probable explanation seems to be that there are minute bubbles of gas in the neighborhood of the electrodes, due to slight generation of hydrogen and oxygen. The phenomena can also be explained by assuming that there is an irreversible polarization present,

*Transactions American Electrochemical Society, Vol. vii, p. 51.

which is a function of the current.* The transfer resistance is greatest in the high acid electrolytes and at low temperatures. Its practical effect is to reduce the gain to be expected by spacing electrodes close together and from increasing the acidity of the electrolyte, and to increase the gain to be expected from heating the electrolyte.

The temperature co-efficient of electrolytes is large and varies with the temperature. Fig. 4 shows the effect of tempera-

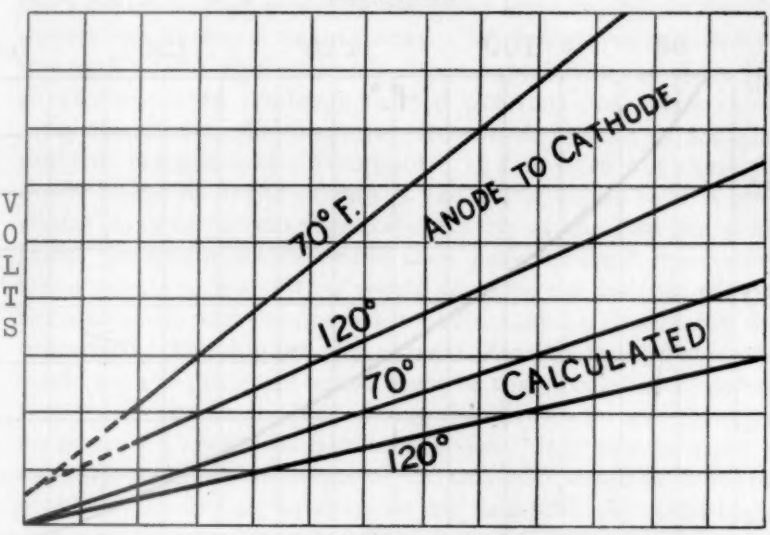

Fig. 3

ture change on a typical copper refining electrolyte. The practical effect of the change in temperature upon the resistance is rather complex. The transfer resistance exhibits a very large temperature coefficient while the contacts and metallic conductors are not appreciably affected. The resultant coefficient figured from the switchboard is approximately 0.5 per cent. per degree Fahr.

Contact resistances are met with at the joints in the main bars and at the connections between bars and electrodes. The joints in the main bars should be equal in conductivity to the bar itself. This standard can easily be attained if the bars are

*Transactions American Electrochemical Society, Vol vii, p. 33.

properly faced. Three or four hundred amperes per square inch of bearing area will give no trouble. The contacts between the electrodes and the main bars are very variable. A single contact will run from 0.000005 to 0.0005 ohm, according to the cleanness of the engaging surfaces and the pressure.

Finally we have a certain amount of counter-electro-motive force present due to the greater concentration of the electrolyte at the anode than at the cathode. This is in general very small, —about 0.02 volt per tank in the multiple system. The anode

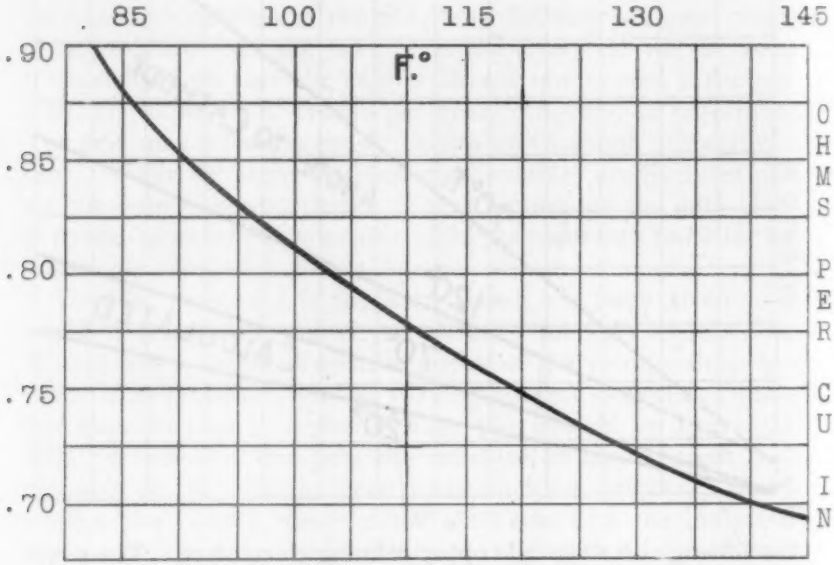

Fig. 4

slimes cause a certain amount of polarization, and if very bulky and adherent it may become serious, starting intermittent gasing and making the tank "crazy."

Tank resistance is therefore made up of a number of factors and, as none of the power applied is absorbed chemically, disregarding the small counter-electro-motive force, it is possible to make any of these factors as small as desired, and it is a commercial problem to determine the most profitable value for each. A rough summary of the relative values of each in practice is as follows:

Metallic resistance	15 per cent.
Electrolyte, including transfer	60 per cent.
Contacts	20 per cent.
C. E. M. F.	5 per cent.
	100 per cent.

The question of what current density to carry is largely one of power cost. Present American practice runs all the way from twelve to thirty-five amperes per square foot. The steady full load on a large power-house gives ideal conditions for the generation of cheap steam power. With high-current density the tank room requires much closer supervision, as there is a greatly-increased tendency toward polarization. It is customary to circulate the electrolyte from tank to tank to maintain uniform composition throughout. If this were not done the heavy liquor from the surface of the anode would form a horizontal layer of increased specific gravity at the bottom of the tank. Different strata would then have different conductivities, crystals of blue vitriol would form on the bottom edge of the electrodes and the operation of the tank be thoroughly disorganized The higher the current density the greater this tendency and the more active must be the circulation. An excessive circulation tends to stir up the silver mud and results in an increased silver loss in the cathodes. It is safe to say that roughly, the silver contents of the cathodes made at a density of thirty amperes per square foot will be double that of cathodes made at half the density. High-current density also means rougher deposition and necessitates more frequent renewal of the cathodes to maintain the current efficiency. Most of the Eastern refineries run at from seventeen to twenty amperes per square foot.

The size of tank is chiefly a matter of construction. The number of electrodes placed in parallel does not seem to bear any direct relation to the current efficiency. This is probably because low efficiency is caused rather by the condition of the deposit or its tendency to sprout and form trees than by local mechanical troubles between single pairs of electrodes. Sixty electrodes in a single multiple tank give no trouble. Various dopes have been tried for controlling the character of a deposit. Ammonium sulphate undoubtedly exerts a beneficial effect in

encouraging smooth deposits. This may be due to some secondary cathode reaction in which the ammonium radicle is momentarily freed. Ammonium sulphate increases the resistance of the solution, however, by driving back the dissociation of the free sulphuric acid present. Organic reducing agents, notably gelatin, have marked effect in restraining the crystalline nature of deposits, but are not easily controlled in copper solutions. The peculiar structures sometimes seen at the cathode are doubtless due to the effect of various soluble impurities in the anode. Often a total change in the character of a deposit can be induced by simply lowering or raising the temperature of the electrolyte.

Comparatively little copper is put upon the market in cathode form, although this is an ideal shape from which to make brass and copper castings. The wire bars and ingots never give a conductivity equal to that shown by samples from the cathodes from which they are made. This is partly due to the absorption of some impurities from the furnace lining and products of combustion, and partly to mechanical pocketing of impurities in the cathodes during the electrolytic process. These particles of impurities are associated with nodules and a smooth part of the cathode is naturally selected as a sample to draw out into wire.

The furnace operation consists in melting down the charge rapidly in large reverberatory furnaces and exposing it to an oxidizing treatment until the bath contains about 6 per cent. of cuprous oxide in solution.* This exerts a strong scorifying action on such impurities as can be slagged. The metal at this stage exhibits a characteristic fracture and is called "set" or "dry" copper. Carrying the oxidation further only results in needlessly slagging copper. The reaction is then changed to a reducing one by means of hydrocarbon gases evolved from green poles thrust beneath the surface of the bath and the copper brought back to "pitch," or when it contains some 0.6 per cent. of cuprous oxide, and gives castings the surface of which neither rises nor falls when "setting" in an open mould. The metal in this state develops the best mechanical properties under subsequent treatment. Underpoled copper simply con-

*Transactions American Institute Mining Engineers, Vol. xxxiv, p. 671.

tains an excess of cuprous oxide as an impurity and suffers in both electrical and mechanical properties. Overpoled copper looks like slightly underpoled copper under the microscope. The mechanical properties are satisfactory, but there is a slight decrease in conductivity and castings are bad, due to the expulsion of gases as the metal sets. An overpoled bath is, however, in a very unstable condition, and it is usual in such a case to start at the beginning of the refining operation and oxidize the metal to set copper again. The chemical reasons for these facts are not fully understood. The fact that molten copper is so sensitive chemically to its surroundings, and that it chills so readily, due to its high thermal conductivity, makes it a difficult metal to handle.

This paper has been written from the point of view of the multiple system of refining. The main points of difference between this system and the series system are in power cost, compactness, and cost of preparing anodes. The power required is practically half as much again in the multiple tank. The series tank has relatively no contacts or conducting bars and the electrodes are very close together, the anodes being thin even plates. To produce such anodes they must be either rolled or specially hand-cast, and the grade of material used must be good. The interest on the metal tied up in process and on the investment in plant is less in the series system. The series system requires no starting sheets, but much closer supervision to keep the quality of the cathodes up. As lead-lined tanks cannot be used in series work, due to the relatively high voltages used, tank maintenance becomes an important item. The fact that large refineries on both systems are being satisfactorily operated bears witness to the close balancing of the pros and cons in each case, although much more material is refined by the multiple than by the series process.

THE JOHNSON SYSTEM OF SELECTIVE WIRELESS TELEGRAPH.

The British Admiralty proposes offering facilities to A. T. Johnson for testing his selective system of wireless telegraphy upon a practical working basis at sea. The characteristic feature of this invention is that when a message is dispatched to a certain point it is impossible for it to be received

by any other than the requisite station, neither can it be intercepted or dispersed during transmission. In this device the inventor utilizes in his transmission apparatus the ordinary Ruhmkorff coil. On the base of this, however, is attached a reed disk. Armatures provided with weighted heads are fitted to this disk, and carry tuning reeds. The electric contact is made in the usual manner. The receiver comprises permanent magnets, strengthened with electro-magnets, and with an arrangement of steel reeds similar to those fixed to the transmitter, and with those on which they can be timed in unison. In transmitting a message the operation at the transmitter revolves the reed disk until the timing reed and its speaking reed are brought immediately in front of the center cone or cones of the electro-magnet. The contact pillar is then placed in connection with the speaking reed so that the vibrations thereof cause synchronous vibrations in the timing reed, which is the indicator. The vibration of this latter reed indicates to the transmitting operator that his companion at the receiver is getting the message satisfactorily, since the indicator must vibrate in unison by the law of syntonic synchronism. Experiments are being made in London with the system daily, and so far have proved successful. It would seem, however, that the great difficulty would be to obatin perfect unison in two stations situated at great distances from one another owing to the liability of the reeds being affected by climatic and temperature conditions which are constantly varying.—*Scientific American.*

THE KNOTH STEEL PROCESS.

Henry Knoth, superintendent of the steel plant at Monterey, Mexico, in a recent patent (U. S., 788,650) proposes that the liquid slag (resulting from an initial heat prepared in the usual manner in a basic open-hearth furnace) be used continually to purify other heats by being returned to the same furnace, the losses in the basic properties of the slag, by continually purifying heats, being replaced by lime or other fluxing materials. Preferably, the unpurified metal (to be acted upon by the molten slag) is introduced into the furnace in a molten condition; or better, blown in an acid converter, in both of which cases the bath, due to the ready condition of the slag, will go at once into action, and the duration of the heat will be considerably reduced. This process is being extensively used at the Monterey Steel Plant, where it is said to be giving excellent results.

The process is intended to operate most successfully when the pig metal is treated in an acid converter; it is claimed that (where the unpurified metal is blown in the converter to 1 per cent. carbon, and then charged into an open-hearth furnace and treated in accordance with the Knoth process) a production of 200 tons of steel in 24 hours can be easily obtained from a 30-ton furnace.

Among the other advantages claimed for the process are the short time of the heats in the furnace, and accordingly the increased life of the furnace hearth, the opportunity to repair the furnace bottom between heats without interrupting the continuity of the process, and the utilization of all the basic properties in the slag.—*Eng. and Min. Jour.*

THE FRANKLIN INSTITUTE

(Stated Meeting, held Wednesday, October 18th, 1905.)

Thermit Practice in America.

By E. Stütz.*

Member of the Institute.

[In this communication, the author gives a somewhat detailed account of the progress made within the past eighteen months, in the introduction in the United States of the Thermit process as applied in various engineering and mechanical arts. The progress has been rapid and apparently the process has proven quite as successful here as abroad.—The Editor.]

It gives me particular pleasure to address a meeting of the Franklin Institute, as it was in this hall that some twenty months ago an opportunity was offered me to explain the possibilities of the alumino-thermic process, which had been developed beyond the experimental stage on the continent of Europe, but which was practically unknown in the United States at the beginning of 1904.

The subject was so new that it did not attract the attention which we (with our greater knowledge of it) thought it deserved, but this impression was dissolved by actual experience. As I went further over the country with the object of introducing the process, I was surprised at the number of men whose acquaintance was important for my purpose, to whom my face was familiar just from this Franklin Institute lecture, so that I may well say that I have seldom talked before so thoroughly representative and competent a gathering.

I am still more pleased to be able to say personally in this place, how highly Dr. Hans Goldschmidt has appreciated the signal distinction conferred on him by this Institute, through the award, by the Committee of Science and the Arts, of the

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Elliott-Cresson Medal. Not only did he very highly appreciate this compliment—the first paid him in the United States—but it encouraged all of us who are connected with the process in this country to continue his work of organizing and developing the numerous new applications in metallurgy and engineering to which the fundamental discovery of the self-continuing reaction between finely-divided aluminum and metallic oxides has opened the door.

When we showed this process of creating 5400° F. by igniting a powder in a suitable vessel, here on this floor (which was protected only by some sheets of asbestos and one layer of brick and sand) we proved that we had a power at our disposal and entirely under our control, which, through the extraordinary speed at which it developed and the wonderful simplicity of the apparatus by which it was controlled, afforded a means of producing results which until then had never been thought possible. Nobody could fail to be impressed by these facts, but naturally the human mind, in all its variations, had still to be guided in the proper direction in which the new power could most advantageously be utilized. The shallow mind saw nothing in the display but a new sort of fire-works. The hypercritical mind saw only the possibilities of non-success. The enthusiast wanted the process used for making anything and everything—from an armor plate ingot to a pin. The man who is always in a hurry thought it too complicated because it was not a machine, ready for use, but required brains, care and perseverance to properly understand and handle it. This latter point—teaching the people to understand the process—has been our principal object and our principal difficulty. There are persons who cannot learn because their minds run in grooves, and there are others who will not learn, because they think that they know better. Both are very likely to attribute non-success in any operation—not to themselves, but to the process.

As it is, the alumino-thermic process does not fit into any of the traditional divisions of the arts. It is a chemical invention which benefits—not the chemist—but the engineer. Some of its more important branches for uniting metals, under the present labor divisions, would fall to the blacksmith. However, it is not a blacksmith's job, but a foundryman's.

I will not to-night show you an actual demonstration of

Thermit, because I may assume that most of you have seen the process in actual practice in some place or other. It is much more my object to tell you how various applications have been developed and turned to use for particular requirements that present themselves in their work to all classes of engineers and for which it offers them the most tangible advantages.

In January, 1904, we brought into this room two short sections of a 7-inch girder rail and we welded them. For commercial reasons it was not found possible to actually do these welding operations on the track until six or seven months later. It was commercially impossible to do such work until we manufactured Thermit in this country, for which purpose an installation was completed in July, 1904.

In this field of track work we were new-comers and competitors of some established forms of joining rail ends for street railways by either an electric-welding or a cast-welding process. The so-called "cast-welding process," which consists in running a heavy sleeve of liquid cast-iron around the end of the rail, had been very successfully introduced and exploited during a period of about ten years. It was at that time undoubtedly the best form of obtaining a continuous rail, and when the work was done under favorable conditions and with great care, it showed satisfactory results. It is hampered, however, by the necessity of melting its iron in close proximity to the track, and therefore has to carry around a large and cumbersome cupola on wheels. The cast-iron has to be carried, by two men, in ladles, along the track, from the cupola to the joint, and poured into cast-iron molds. In order to obtain the desired cohesion between the sleeve and the rail ends, it is necessary that the latter be very clean and free from moisture, and that the amount of liquid metal be very large indeed, in order to develop the necessary temperature. For girder rails, the weight of this sleeve is therefore between 180 and 200 pounds. The weight of such an anvil at any point of the rail has a bad influence on the evenness of wear of the track, and this disadvantage is increased when the anvil effect takes place at the joint.

Against this process we took the field with the small crucible (about fifteen inches high) in which, in half a minute, we produce a quantity of eight to ten pounds of highly super-heated liquid steel, which we could run directly around the rail ends.

With these ten pounds of super-heated steel, at a temperature of about 5400° F., we obtained an absolute fusion of the rail material with our own steel.

We have to melt just the quantity of steel that suffices for each joint. We need not wait until we have some seventy or eighty joints ready for operation, at the risk of losing a large part of the metal in case of an interruption, but we can take each joint separately and the efficiency will always be the same. We obtain the result by an absolute fusion of the rail ends with the small shoe of thermit steel, and in doing so, obtain an absolutely solid joint with an increased area of electrical conductivity. Our whole outfit consists of this crucible, with welding

Fig. 1. Rail welding at Cleveland, showing mold in position.

portion which contains the necessary amount of Thermit for each particular section of rail and the pair of mold boxes (also made specially for each section of rail) which exactly fit the section from either side. The molds are made in a sheet-iron box, of a mixture of sand and clay or sand and flour, and tamped over a wooden model, so as to get the exact outline of the steel shoe that is to be fused on. These molds require great exactness of detail, so as to have the necessary amount of steel properly distributed over the whole welding surface. The mold is the most essential part of the equipment. It must

be carefully made, so as to be porous and dry. Being of a somewhat fragil material, it requires careful handling in fitting it to the rail, which should previously be heated to drive out the moisture. It must be kept covered until the operation actually begins, to prevent any dirt or sand from dropping into it, and it must be extremely carefully luted at all contact points with the rail, so as to prevent any leakage. The importance of preventing a leak arises not only from the loss of the thermit steel, but also from the loss of metal it is intended to weld. The hot steel running out of the crucible, through the gate and around and up the web of the rail, will melt the material with which it comes into contact and liquefy it. The momentum

Fig. 2. Rail welding at Cleveland, showing Thermit reaction.

with which the steel drops down into the mold will necessarily carry a part of it up through the mold. A leak that develops will then drain out—not only the thermit steel itself, but also the metal of the rail with which it has come into contact, and leave an ugly hole in its place. It is not that the rail has been burnt in this place, but simply that the scouring action of the super-heated steel has washed away the original metal, with which it would have been combined to one homogeneous mass if it had been prevented from escaping.

Some thirty cities in the United States have tried this pro-

cess up to the present, some 13,000 joints having been welded —some on a large scale, like Cleveland, Ohio, where about 3,000 joints were put in this year, after a sample quantity that stood through last winter, and Holyoke, Mass., where about a thousand points have been put in after the same test of 160 joints last year.

In both cases the street railway company trained its own men in the application of this process, which they operate quite independently from the Goldschmidt Thermit Company, buying from them only the necessary quantity of welding portions and the necessary number of crucibles. They have trained their

Fig. 3. Nine-inch welded rail.

"gangs" of four men, who will in the course of a day make about thirty joints. They make their own molds, dry them and take them to the job in a special car set aside for this purpose. They are absolutely independent of the weather or any other adverse conditions. If the paving is delayed through an accident, it does not matter to them. They do not waste any material, whatever. If they have a small piece of track to weld, it is as economical to them as a large piece. They have the matter entirely under their control, to arrange their work as suits them best. They need not interrupt their traffic, joints having been welded on the track with cars running at ten min-

utes' headway. Once the weld has been made, there is, as a rule, no need for any grinding down, as the effect of the weld does not raise the head of the rail. The peculiarity of the process is that while the liquid steel surrounds the web and foot of the rail, the slag entirely covers the head and so brings the whole section to a practically uniform temperature. The slag does not adhere to the head of the rail, but is knocked off easily with a crow-bar. No air can get at the weld, and this is the reason why no chemical change takes place in the head of the rail. The most careful experiments have shown that the head of the rail does not get softer. Micrometer caliper measurements of the depth of indentation made by a center punch taken at the welded joint and three feet away from it showed the head of the rail at the welded joint to be, if anything, harder than the head of the rail three feet away from it. These tests were made at Baltimore.

In New York City some 300 to 400 joints have just been completed on parts of Grand Street.

It will be seen that the operation of welding rails by the thermit process has therefore been reduced to an entirely mchanical one. The mold model and mold boxes are supplied, the necessary amount of Thermit is calculated and weighed off by the Goldschmidt Thermit Company. All that has to be done is to dry the rail, place the mold, and over it the crucible, then tap the crucible. These mechanical operations—requiring certainly intelligent care—are not beyond what can be expected of a track foreman.

It is a more difficult proposition when the shape of mold and the quantity of Thermit have to be calculated by the individual operator. Such is always the case in repair work. It is not possible—even when supplied with very exact blue-prints—to always give instructions so minutely and definitely as to avoid a mistake in the construction of the mold or the quantity of Thermit. All the more is it to be admired with what thoroughness and intelligence a large number of mechanics in this country have studied the question and have obtained entirely successful results—merely by closely observing the instructions and rules laid down in the literature supplied by us. The most important case in point of that of welding frames of locomotives. These frames are of wrought-iron or cast-steel and

vary from $3\frac{1}{2}$x$3\frac{1}{2}$ to 5 x 6 inches in section. They are very liable to break and their repair without dismantling the engine means a very large saving—not only in time, but in actual labor and material. In order to repair a frame by the old methods an engine had to remain out of commission for a fortnight and the actual weld cost between $250 and $300. The work by Thermit is now done (as has been amply testified by statements of various engineers) in two days, at a cost of about $50.

Fig. 4. Welding locomotive frame.

The principle guiding the construction of the mold is that the thermit steel must not impinge directly on the casting to be repaired, but must run through the gate to below the lowest point and be made to rise from there, through and around the fracture, enclosing the latter with a strong collar, which fuses with the material of the frame. The first steel running out of the crucible into the mold, however, becomes chilled when coming in contact with the casting, which—even when pre-heated—

has a considerably lower temperature than the thermit steel. This chilling effect can only be overcome by a sufficiently large supply of thermit steel, so that the cooler part of the liquid mass is driven up into the riser and is replaced in the collar surrounding the frame by metal which has practically the full temperature it received during the reaction.

The important point in making welds by Thermit is to obtain a good circulation of the thermit steel, around and through the piece to be repaired, and after careful observation, the rule has been made that to ensure a really good weld, the quantity of Thermit should be twice that which would be sufficient to fill the actual collar which is to be welded on.

The troubles encountered in making these welds were nearly all attributed to the fact that not sufficient Thermit had been used or that the mold was constructed in such a manner that there was not sufficient vent for the air, or, finally, that the mold was either not sufficiently porous or sufficiently dry. All these conditions are absolutely essential.

If sharp sand and ordinary brickmakers' clay are used for molding material, they must be mixed in equal parts and must be *burnt* dry. To only skin-dry such molds means metal full of blow-holes, as the moisture of the back of the molds is sure to turn into steam and force its way out into the liquid steel.

For small operations, satisfactory results have been obtained by mixing ten parts of coarse sand with one part (by volume) of so-called "no grade" flour. These molds cannot be *burnt* dry, as they would go to pieces, but through the action of the steel the flour gets burnt together with the sand and carbonizes to such an extent as to protect the back parts of the mold. With molds made in such a manner, perfectly sound pours have been made in street railway work.

Wherever available, fire-brick cut down to size and carefully luted, offer a very convenient material for molds. They do not require hard drying, although even such a mold ought to be warm before being used.

Among the railways which have been particularly successful in welding locomotive frames, must be mentioned the Portsmouth shop of the Seaboard Air Line, the Elkhart shops of the Lake Shore & Michigan Southern, the Allston shops of the Boston & Albany, and the Richmond shops of the Richmond,

Fredericksburg & Potomac, records of which are available. There are a number of other lines which are using Thermit extensively, but from whom reports cannot be obtained.

Among the preliminary tests made by various railroads, I may mention one at the Elkhart shops, where a welded bar $2\frac{1}{2}'' \times 3\frac{3}{4}''$ stood a pressure of fifty tons on supports twenty inches apart, before breaking, after two sides of the reinforced collar had been machined off. It is essential that the reinforced collar be left on wherever at all practical. The original break is due to a structural defect. With the break in such a position as to necessitate the entire removal of the reinforced collar, it is too much to expect that the mere bridging of the broken ends, by means of thermit steel, would entirely overcome this weakness.

It is important, in welding locomotive frames, to allow for equal shrinkage of parallel parts, and it is also very advisable to "spring" the ends to be welded apart, before the operation, in order to let them come back when the iron begins to set.

Broken spokes of driving wheels are welded in the same manner and, as a matter of fact, a mechanic familiar with the process is able to save untold money in his shop by judicious application of the process.

Among repairs, of course the most important and most brilliant are those pertaining to marine engineering. An account of the welding of the Clyde Line steamer "Apache," of 4100 tons, will, I think, be of interest in this place.

The Apache was placed in dry dock about 1 P. M. on July 28, 1905. The dock was a graving dock, and the water was entirely pumped out at 2.15 P. M. Propeller wheel was removed and shaft drawn in to the hull, for the purpose of examining same for the benefit of underwriters. It was not necessary to remove the wheel and shaft to perform the work. The shoe or skeg had been patched. Two large plates had been placed—one on each side—and top and bottom plates had also been put on, forming a box, as it were, around the break. These were removed at 3.20 P. M. The break was found to be about $18\frac{1}{2}$ inches from the after side of what is termed the "stern post" (not the rudder post).

A mold and mold box had been previously prepared. Allowances were made in the clay mold, so that it could be fitted

tightly to the skeg. It was decided to have an aperture of clearance in the break, for the metal to flow through, and as it was impossible to spread the broken parts, a series of holes one inch in diameter were drilled vertically through the skeg—nine in number—following the line of the crack. The section to be welded measured 6¾ inches vertically by 11 inches horizontally.

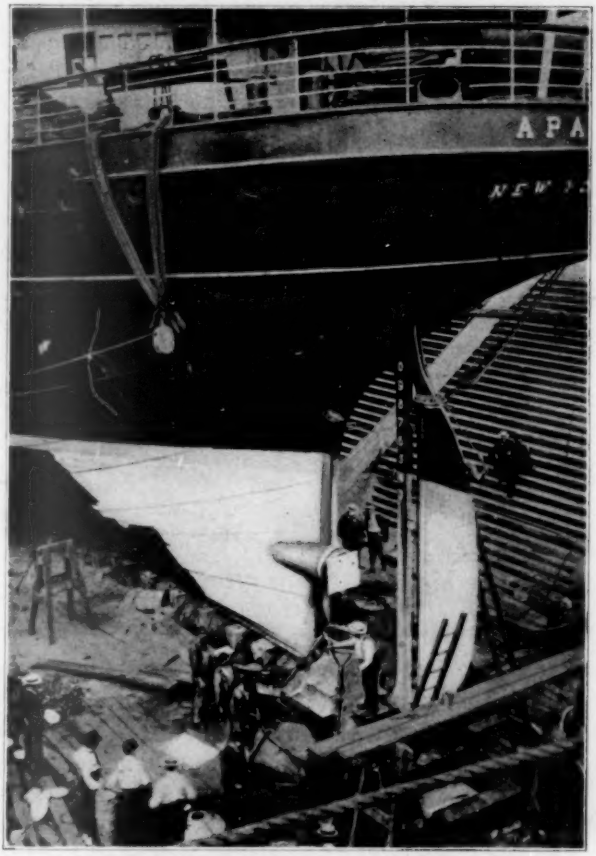


Fig. 5. Welding shoe or skeg of Steamship Apache.

The men with air drills were started to drill these holes as soon as the patches were removed, and as this work would take them long into the night, after darkness set in, nothing further was done on the work the first day.

Next morning the skeg was heated to a red heat and mold box taken from the furnace and put in place. A foundation was built under the mold box, and a riser of brick, forming a base with a wall about one brick wide and about 12 inches high, was formed around the mold box, forming a basin, into which moist sand was poured. The joints were well luted and sand well packed up around the luting, so that the entire mold was thoroughly protected in case of any leaks. The mold had been so arranged, as the section to be welded was very broad (11 inches) it was thought best to have it well ventilated, and five risers were prepared, the riser box being very shallow, with a spout for the slag to run off, and a trough in the sand leading to a pit which was formed at one side.

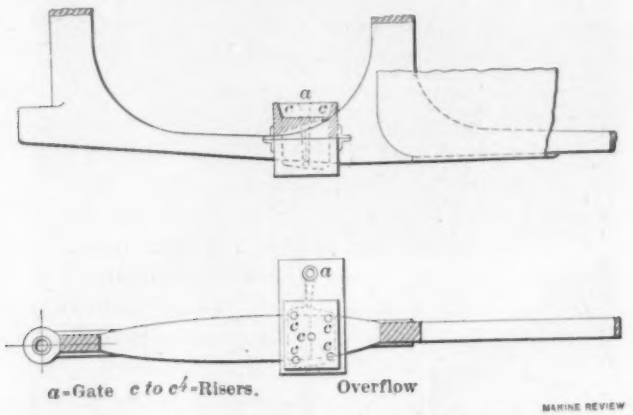


Fig. 6. Mold and mold box used in welding operation, Steamship Apache.

A small open furnace had been prepared and placed on top of the mold, in which a charcoal fire was burnt. Air from the compressed air supply on the dock was utilized for draft, and hot gas was forced down through the gate and up through the riser. While this was in progress, the crucible was put in place, the ordinary tripod being used. There were placed into the crucible 475 pounds of Thermit, together with 100 pounds of steel punchings—the punchings and the crucible having previously been heated. The mixture of the thermit, punchings and manganese was performed by pouring in each consecutively, each being well stirred as it was placed into the crucible.

Owing to the pre-heating, the final reaction was retarded

until 4.35 P. M., when the Thermit was ignited and the reaction took place. Thermit was then used in feeding to the risers and gate, feeding in gradually, maintaining continuous reaction for several minutes, to relieve the mold of gases which might form in the body of the weld. This proved to be very effective, as much gas was seen to come from the mold through the riser and gate during the feeding process. This was continued until fifty pounds of Thermit had been consumed.

The mold was allowed to remain in place over night, gradually cooling, and was then annealed by surrounding the weld with a box, in which a charcoal fire was prepared. This fire was continued about five or six hours, allowing the weld to cool gradually. In the morning when the mold boxes were removed, the gate and risers were trimmed off, and the grain of the metal appeared to be of exceptionally good quality and cut very freely with the air tools. The shaft and propeller wheel were then put in place and the vessel was ready for docking at 10 A. M. of the third day.

A number of other repairs belonging to marine engineering have been successfully made—among others, one of a rudder stock five inches in diameter, which was welded with fifty pounds of Thermit and ten pounds of steel punchings. The collar, in this case, had to be entirely removed.

We have also heard lately of a successful weld of a 7″ shaft of a steamer at Columbus, Ga., which was made without any verbal assistance from the Goldschmidt Thermit Company.

An improved method of making such welds has lately been developed at the Essen works. The mold is placed in position after the fracture has been opened out and cleaned, but before it is heated. A suitable coke stove is then placed over the mold, and connected with it is a blower, which drives the fire gases through the coke, around the piece to be welded, and brings not only the latter, but also the mold to a high degree of temperature, thus facilitating the weld and eliminating all possibility of moisture in the mold. This process has been found particularly valuable for the repair of pieces of great diameter.

Most of the defects in castings, however, are naturally detected before these leave the foundries, and it is natural, therefore, that steel foundries were among the first to appreciate the great value of our process for them, as it enabled them to save a large

number of castings. Such defects, although small, entirely destroy the value of a casting. The use of a process like ours, which repairs the defect without in any way diminishing the strength of the casting or interfering with the possibility of machining it, is a practical necessity to steel foundries.

Some important repairs of gray iron castings are worth mentioning. At the Renovo shops of the Pennsylvania Railroad, a hydraulic wheel press was repaired, the part welded having to stand a pressure of sixty tons per square inch The original "strong back" holding the wheel against which the axle was pressed, was not strong enough for the purpose until repaired by Thermit.

Fig. 7. Complete weld of shoe or skeg of Steamship Apache.

The spoke of a fourteen-feet fly-wheel at the works of C. M. Robertson & Co., Montville, Conn., was repaired by Thermit. In the course of moving a segment of the wheel into place, the supporting chain broke, allowing it to fall and crack a spoke, very close to the rim. The entire wheel weighed 11,000 pounds and measured fourteen feet in diameter; the face of the wheel was twenty-five inches in width and two inches of metal in the rim. The segment with the fractured spoke weighed 5500 pounds, and measured seven feet in diameter. The fracture extended diagonally across the spoke. At one point from the inside of the rim to the fracture the distance was one inch.

At another point it was $1\frac{3}{8}$″ away from the inside of the rim. The spoke was elliptical and measured $7 \times 3\frac{1}{2}$ inches.

It was decided to cast around the fracture a collar of thermit steel $4\frac{1}{2}$″ in length and $\frac{3}{4}$″ in thickness. The collar was to fit directly against the rim at the juncture of the spoke and that part. It was calculated that fifty-eight pounds of Thermit and ten pounds of punchings would make the weld. Six half-inch holes had been bored along the break, because if the metal had been cut away to form a distinct space, there would have been some difficulty in keeping the necessary parts in alignment.

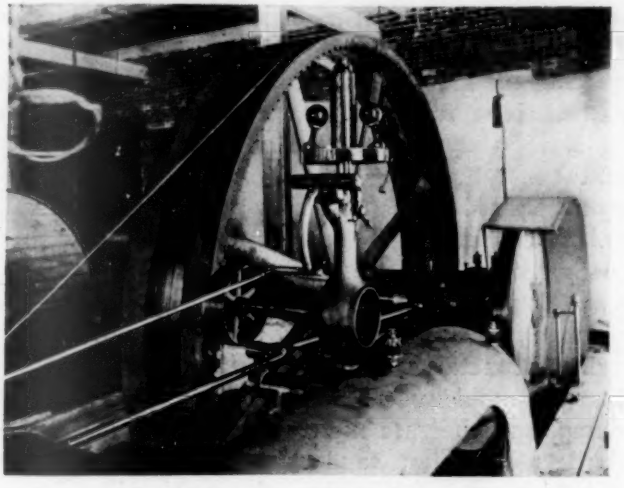


Fig. 8. Welded spoke of flywheel, Montville, Conn.

The two halves of the mold were too large to be put into the boiler furnace or into the ash-pit to dry. A temporary furnace was therefore built, using for the purpose a piece of heavy plate 40″ square, which was supported by brick work construction, standing eight inches from the ground. The supporting wall was closed on the two sides and open on the other. Around the top of the plate, at the outer edges, there were placed three courses of bricks. The two halves of the mold were placed on the plate, and below it a wood fire was started at about noon time. After burning for about two and a-half hours, the mold was covered with charcoal, which was packed all around it. The charcoal was then ignited and the whole covered with an-

other iron plate. The wood fire was kept going until three o'clock the following morning. At 8 o'clock the same morning the fire had died down, but the molds were still hot. This treatment completely burned the mold, resulting in a very quiet action when the steel was poured into it.

The inward curve of the rim prevented the crucible being placed directly over the gate, an extension of the gate was made by taking a sheet metal tube 4″ in diameter and 10½″ long and cutting the ends to an angle of about 45°. It was rammed full of moulding sand, around a ¾″ gate pin. It was afterwards dried in charcoal fire.

A charcoal fire was built about the spoke and kept burning for from two to three hours.

In placing the mold in position, a double length of ordinary twine was taken and around it was rolled moist clay, forming a rope about the thickness of one's little finger, to guard against the metal running out. This was put around the inner edges of the mold boxes, so that when they were clamped together, the clay rope would be squeezed between them, thus effectually sealing all joints. The quantity forced out of the joints by the pressure of clamping afforded a good foundation to build upon when finally luting the outside of the junctions. Not a drop of metal got outside of the mold.

When the mold was fitted, luted, and carefully banked up with damp sand, the gate extension was put in place. Where it joined the mold, damp sand was carefully packed around it. It was held securely by bricks. A trough of bricks and sand was formed at one side of the mold, to conduct away the slag which would be in excess of the capacity of the riser. The charge was then ignited and burned down normally. When the sand and mold were cleared away, there was shown a smooth collar and a good looking weld.

Work with gray iron castings requires more experience in regard to pre-heating and cooling down gradually. More Thermit is necessary to effect the weld in this case, on account of the hard, glassy scale on such castings, which resists fusion, and an addition of ferro-silicon (about 2%) is advisable, to prevent hard spots at the line of junction between the thermit steel and the cast-iron.

Some of the smaller defects have even been repaired without

the use of a crucible, by placing a "pouring cup" over the defect and igniting the Thermit directly in this cup.The cup, of course, must be absolutely dry and must be carefully luted from the outside. Even then there is a risk of the slag not separating entirely from the steel and in that manner preventing a weld. From some experiences, however, it would appear as if this danger were more theoretical than practical. The peculiar shape of the pouring cup no doubt facilitates the displacement of the slag by the heavier weight of the steel.

While in all these welding operations the heat of the slag is either wasted or entirely subsidiary to the heat action of the thermit steel, there is one application of the thermit process which is highly interesting because the manner of proceeding

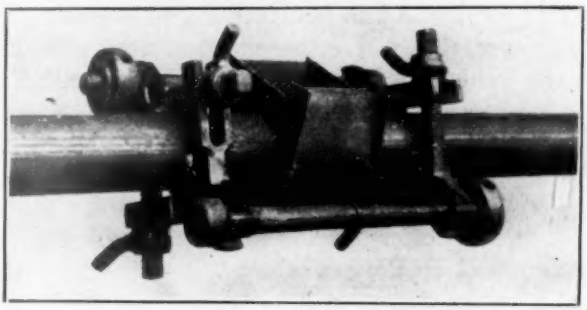


Fig. 9. Welding pipes in horizontal position.

differs entirely from that outlined up to the present. The heat of the thermit steel (unless properly controlled and guided in a mold) will burn through, and destroy any casting. Nevertheless, a method has been developed by which wrought-iron pipes can be welded without banking up the interior. Of course, of the thermit steel were run directly on to the thin walls of a pipe, it would burn through. In this case the joint of a pipe is surrounded by a sheet-iron or cast-iron mold, into which the slag resulting from the reaction is poured first. This slag adheres to the surface—not only of the pipe, but also of the mold, and protects both from being washed away by the thermit steel. The reaction is made to take place in a crucible with a flat bottom and the contents are poured over the lip, so that the slag runs out first and is followed later by the steel. The pipe ends are held in clamps and about a minute and a-half

after the pour the clamps are drawn up and an absolute butt weld is obtained, without any change in the dimensions of the pipe.

Work of this kind was done recently in New York City, for the Manhattan Refrigerating Company. The pipes were laid in the ground, on 14th Street, and are used as service return pipes in the delivery of liquid ammonia—180 pounds pressure—to various cold storage houses along the street. Twenty-nine $1\frac{1}{4}''$ and twenty-seven $2''$ joints were welded. The pipe was welded on the ground, the lengths varying from 40 to 100 feet, then placed into the ditch, cuts made for connections and the final welding done with the pipe in place. On the $2''$ line an expansion bend was placed, while on the $1\frac{1}{4}''$ this was not thought necessary. Both lines were tested out before being thrown into service and no failures showed themselves. It was noted, however, that where the pipe was very thin, blow-holes were in the welded section. A large blister showed itself in a section of the weld. This was noticed at three different times, showing defective pipe. These defects were, of course, cut out, and additional joints made.

If the application of the thermit process for the repair of gray iron castings offers certain difficulties and requires special care, the process, on the other hand, provides gray iron foundries with a ready means of improving their metal, as well as their castings, and avoiding any accidents through dull iron. To mention the latter point first, the reviving of dull iron in the ladle is a simple operation. The Thermit, for this purpose, is placed into cylindrical cans, so constructed as to be easily attached to an iron rod. The can, in this case, contains some ignition powder, as the temperature of liquid cast-iron is not sufficient to start the reaction. The rod with the can at its end is thrust down to the bottom of the ladle, where the reaction commences and permeates the contents of the whole ladle. A small can containing $1\frac{1}{2}$ pounds of Thermit is sufficient to melt 40 pounds of steel borings in an 800 pound ladle, so that one can is also sufficient to revive a ten to twelve hundred pound ladle of dull iron.

There is absolutely nothing explosive in this application, the result being entirely due to the very high temperature created in one place, which communicates itself to the whole metal bath.

In a similar way Thermit can be used to keep open the risers and so do away with the danger of shrinkages just at the point where they are most liable to occur—namely, near the junction of gate and casting. As soon as the liquid metal appears in the channel between the casting and the riser, a paper parcel containing Thermit with some ignition powder at the bottom, is thrown into the riser, and by increasing the temperature of the metal at that point, considerably increases the effectiveness of

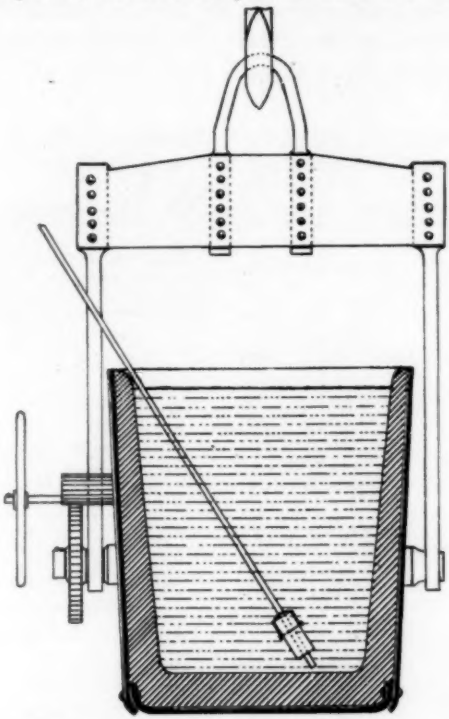


Fig. 10. Introducing Thermit into the ladle.

the riser, and furthermore makes possible a reduction in the size of the riser.

Both applications have found considerable favor with a number of foundries.

Where there is a question of obtaining particularly dense castings, such as are used for cylinders and valves, a special Thermit is recommended, which contains a slight addition of titanium. The Thermit is placed in cans in a manner similar

to the previously describel "semi-steel," or riviving can. The titanium is added to the thermit—not in order to alloy it with the cast-iron, but on account of the affinity of this element and nitrogen. A chemical, automatic poling action is started thereby and the fluidity of the iron is greatly increased, giving the casting greater density and a finer grain. The temperature of the entire ladle is not much increased, as the quantity of Thermit brought to reaction is only from $\frac{1}{16}$ to $\frac{1}{4}$%. Tests of pours made from the same ladle before and after a titanium-thermit reaction, made at the Pennsylvania Malleable Company's Works, McKees Rocks, Pa., will be of interest in this connection.

RIEHLÉ BROS. TESTING MACHINE CO.

Tests on Malleable Iron Bars Cast at Pennsylvania Malleable Co.'s Works, McKees Rocks, Pa.

BEFORE TITANIUM-THERMIT REACTION.

	Dimensions.	Ultimate Strength, Pounds.	Deflection.
No. 1—1	1.000 x .999	4,100	1.00″
1—2	.995 x .999	4,500	.98″
1—3	Lost in anneal.		
2—7	1 060 x .998	4,540	1.28″
2—8	1.012 x 1.006	4,610	1 40″
2—9	1.006 x 1.005	4 500	1 40″
	Average before treatment.	4,450	1 212″

AFTER TITANIUM-THERMIT REACTION.

	Dimensions.	Ultimate Strength, Pounds.	Deflection.
No. 1A— 4	1.011 x 1.010	5,920	1 30″
1A— 5	.999 x 1 000	4 260	1.27″
1A— 6	.989 x .995	4,850	1 55″
2A—10	.995 x .996	4.620	1.47″
2A—11	.998 x .996	4,410	1.37″
2A—12	1.011 x 1.000	4,810	1.44″
	Average after treatment.	4,811	1.60″

In concluding, I venture to think that the practical advantages due to the use of our process will become more and more known, and that by a free discussion of personal experiences, all interested in the process will be encouraged and benefitted.

Improved System of Concrete Piling.

[*Being the Report of the Committee on Science and the Arts on the Invention of Frank Shuman. Sub-Committee, Prof. L. M. Haupt, Chairman; John E. Codman, Louis E. Levy.*]

[No. 2302.]

The Franklin Institute, acting through the Committee on Science and the Arts, investigating the merits of the "Concrete Pile," by Frank Shuman, of Philadelphia, Pa., reports as follows:

The exhibits furnished in this case include the following patents:

No. 733,286, issued July 7, 1903, for Removable Pile for Forming Concrete Piling, containing sixteen claims.

No. 733,287, issued July 7, 1903, for Process of Making Concrete Piles, containing two claims, differing from one another only in the "permitting said concrete to remain without disturbance until it becomes set."

No. 733,288, issued July 7, 1903, for Removable Pile for Forming Concrete Piling, containing twenty-two claims.

No. 733,335, issued July 7, 1903, for Process of forming Openings in the Ground, containing five claims.

No. 733,336, issued July 7, 1903, for Process of Forming Concrete Piles, containing four claims.

No. 733,337, issued July 7, 1903, for Process of Forming Concrete Piles, containing five claims.

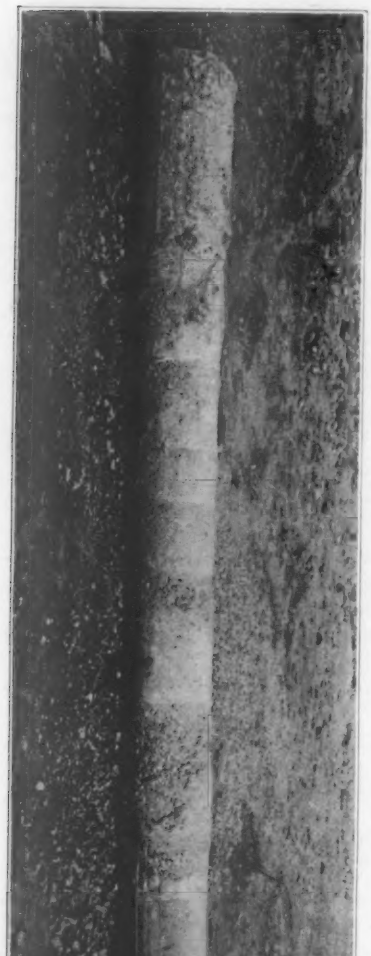
No. 735,680, issued August 4, 1903, for Process of Making Concrete Piles, containing three claims.

No. 739,268, issued September 15, 1903, for Process of Making Concrete Piles, containing eighteen claims.

Also a prospectus issued by the Simplex Concrete Piling Co., describing work actually done at the Washington Barracks, where about 2000 piles were driven and tested to the satisfaction of the U. S. Engineer officers in charge, and several other patents relating to the invention.

From these data and after an interview with the inventor, and after due consideration, your Committee finds that in a general way

The invention consists of two parts, viz.:



Concrete pile 13 feet 2 inches long by 14 inches diam. Dug out intact after test.

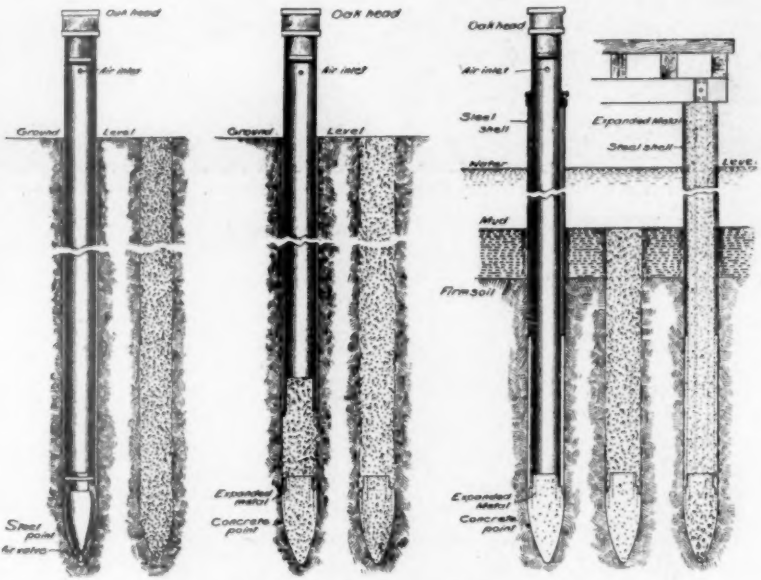
1. A tool for the formation of holes in the ground to contain concrete or other plastic materials, said tool consisting of a suitable hollow shank having a head or point of a larger diameter, and being of an ovidal form, shaped like a shell used in gunnery, riveted to it. The shell is also open at both ends to admit air below the point when the tool is being withdrawn. During driving the hole at the apex is closed by a loose plug, called a valve, which drops out when the form is raised and thus relieves the suction from the vacuum and permits the removal of the pile-former with very small power.

2. The several devices for the filling of the holes with concrete or other material and for holding it in compact position in loose or permeable soil, said device consisting of casings or tubings, which can be removed readily after the concrete has set, and which is designated here as cofferdaming.

The patents therefore cover the process of making the piles and the tool for the formation of the holes or mould for them, and are covered by no less than seventy-five claims,

many of which the Committee believes might be omitted to advantage as being redundant.

STATE OF THE ART.—The use of piles, or piers, whether of earth, stone or other minerals, or of vegetable or metal substances is quite old; the previous perforation of the soil by the driving of a preliminary pile, which is subsequently withdrawn to permit the substitution of other material for the final structure is likewise well known, and hence the merits of this process must consist in securing a better result in less time, or at



Various Systems of Concrete Piling.

less cost, or both, and thus bringing it within a range of greater economic possibilities.

The specifications state that the invention "Relates to that method of forming piles of concrete or cement, which consists in first driving a preparatory pile into the ground, then withdrawing said preparatory pile, and then filling the opening formed thereby with fluid or plastic concrete or cement, which, when it becomes set will form the permanent pile." "The object of my invention is to so construct the preparatory pile that the same can be driven or withdrawn with the exercise of

Concrete points for long 17-inch diam. piles. Engineers' School, Washington Barracks, D. C.

Preparatory pile removed, leaving hole ready for concrete.

much less power than is required when piles of this class, as heretofore constructed, are used."

This greater ease of operation is accomplished largely through the use of the enlarged head which permits the pile to be driven much more readily and be withdrawn with less difficulty and delay than by existing methods. In some instances it has been found advantageous in practice to substitute a solid, concrete head of larger diameter than the driving rod, instead of the steel shell and to leave the head in the bottom of the hole which is filled up with the concrete as the tube is withdrawn, the tamping being done by a plunger passing down the well.

In view of the manifest economies and advantages of this method of obtaining substantial foundations in all classes of soils and under adverse conditions of weather, the Committee recommends that the inventor be awarded the John Scott Legacy Premium and Medal.

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, January 6, 1904.

Attest: WM. H. WAHL, *Secretary.*

AN INDEX TO HYDROGRAPHIC REPORTS.

An index to the hydrographic progress reports of the United States Geological Survey from 1888 to 1903, which has been recently copied by John C. Hoyt and B. D. Wood, will be of interest and service to many persons.

A systematic study of the surface waters of the United States was started by the hydrographic branch of the United States Geographical Survey in 1888. A large part of this work has consisted of measurements of the volume of flow and study of the conditions affecting it. The data collected each year have been published in the Director's annual report, as a bulletin, or as a water-supply and irrigation paper. As the hydrographic work in most localities has continued during several years, the results of the investigations at any one point are scattered through a number of publications, and the only guide to these data has been the individual indexes of the numerous reports. With the growing interest in the commercial development of the hydrographic resources of the country the demand for these data collected by the Geological Survey has rapidly increased, and in order to aid those wishing to use them this index has been prepared. It is published as Water-Supply and Irrigation Paper No. 119, and may be obtained, free of charge, on application to the Director of the United States Geological Survey, Washington, D. C.

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MOISTURE AND FURNACE RESULTS.

At the Liége Metallurgical Congress, M. Divary, of Schneider & Co., Creusot, France, gave some interesting information on the occasion of the discussion of Mr. Gayley's dry air process. The observation was made for many years at Creusot that consumption of coke increased and the output of the furnace decreased in summer as compared with winter, and in 1901 records were kept, which in August, 1902, led to a first study. The result of this study was that an economy of 50 to 60 kg. of coke per ton of iron seemed in sight if the furnace was blown with air saturated at 0 degrees Celsius in place of hot and humid air during the summer months.

These researches were continued, and since the difference in consumption of coke observed during one year seemed larger than those justified by calculation it was determined to carry out the system of drying the air by freezing. This was submitted in September, 1903, to several designers of ice machines. After their figures had been received other questions claimed the attention of Schneider & Co., so that the programme was not immediately carried out, but instructions were given to the blast furnace department to observe daily the humidity in the air and the corresponding fuel consumption under conditions guaranteeing accuracy. Three times per day the moisture was observed in the blowing room.

During the year 1904 the charge remained practically the same, the two furnaces, Nos. 2 and 4, running on Basic Bessemer pig. The results are shown in the following table, the first column showing the average amount of moisture per cubic meter of air blown in during the month, the second column the increase in the consumption of coke as compared with that of the dryest month, and the third column showing the average production per furnace for 24 hours:

	Moisture in blast. Gr.	Increase in coke consumption. Kg.	Average furnace product. Tons.
January	6.3	0	90.5
February	6.6	10	88.7
March	7.6	13	87.2
April	7.8	47	81.2
May	10.0	56	78.3
June	11.7	103	75.7
July	13.0	133	70.0
August	12.0	90	76.6
September	9.3	55	90.0
October	8.0	28	86.0
November	7.6	25	86.5
December	7.0	35	88.5

At Creusot the speed of the engines is not lowered in winter and the blast is always heated to the same temperature summer and winter, being an average of 752 degrees Celsius.

The figures agree very closely with those of Mr. Gayley and hold out undoubtedly the results to be obtained from drying blast furnace blast.—*Iron Age.*

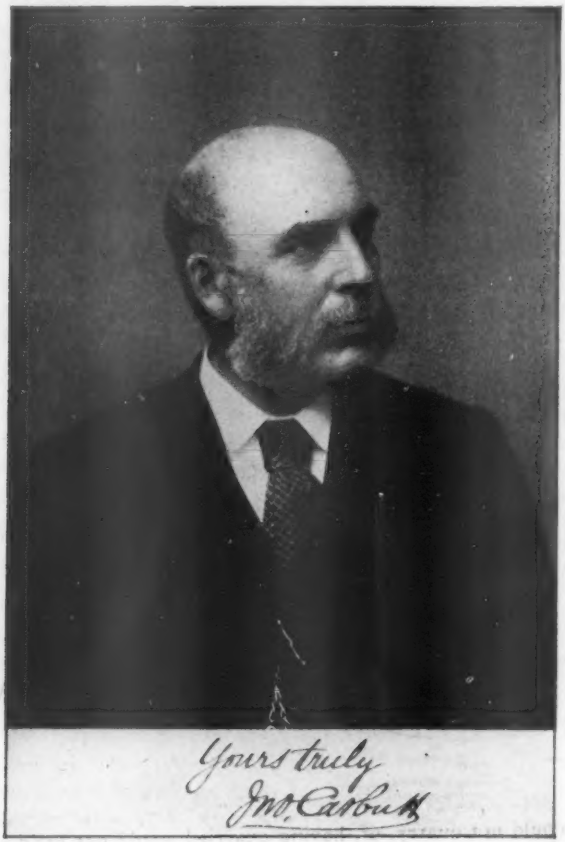
In Memoriam.

John Carbutt.

John Carbutt, who died at his residence, in the Germantown district of Philadelphia, on the 26th of July ultimo, was born at Sheffield, England, December 2d, 1832, and emigrated to this country in 1853. He was one of the early pioneers in that great advance of the photographic art which has followed the introduction of gelatine dry plates. His contributions to this art industry began as early as 1868, when he successfully used gelatine in place of collodio-albumen in the preparation of dry plates in his photographic practice in Chicago. He had previously gained a fruitful experience in the application of dry-plate photography as official photographer of the Canadian Pacific Railway during the building of that road. In 1871 Mr. Carbutt took up the gelatine intaglio printing process, known as the Woodburytype method, and established himself in Philadelphia to work it commercially. In the prosecution of this enterprise he devised numerous and, in some respects, radical modifications of the process to meet the exigencies arising from American climatic conditions and had fairly overcome these difficulties when the development of the less complicated photo-collotype processes led him to abandon the undertaking. Mr. Carbutt then again turned his attention to the preparation of gelatine dry plates and by 1879 he had established a factory for that purpose and put on the market the first American product of this kind.

The Carbutt plates were soon followed by those of other makers, but in certain special classes, notably in plates for lantern slides, they have held a leading place and maintained a widespread reputation. It was through Mr. Carbutt's initiative that the standard size of $3\frac{1}{4}''$x4″ for lantern slides has gradually become prevalent, instead of the varying and smaller sizes formerly in vogue. Mr. Carbutt has also to be credited

with a distinguished part in the development of the chromo-photographic processes, his researches in this direction having led to his introduction of orthochromatic dry plates at a period apparently antedating any other maker. His service in the production of accurate color filters and his contributions to the science of the subject have been notable factors in the ad-



vancement of the art, and in this field generally John Carbutt's work has been of large importance and has left a permanent mark.

Mr. Carbutt was an active member of the Franklin Institute, and for some years a member of the Committee on Science and the Arts. He was the first President of the Photographic Asso-

ciation of America, and did much to effect its successful organization. Also he was an active member of the Photographic Society of Philadelphia. He was an accomplished master of the chemistry of his art and a most industrious worker. A man of genial personality, his efforts had gained him a well-earned competence, but this, unfortunately, proved a less permanent acquisition than his equally well-earned reputation.

LOUIS E. LEVY.
SAMUEL SARTAIN.

THE USE OF COPPER IN DESTROYING TYPHOID ORGANISMS, AND THE EFECTS OF COPPER ON MAN.

In the American Journal of Pharmacy, Prof. Henry Kraemer excellently discusses the effects of water treated with copper on man. His conclusions may be summarized as follows:

1. It is pretty well established that the typhoid organism is disseminated not only through water, but also through air and food, and may retain its vitality for a considerable period of time.

2. Typhoid organisms in water are eliminated by filtration, boiling, and certain biochemical methods. Of the latter, the use of copper, as proposed by Moore and Kellermann, is probably the most efficient and at the same time most practicable.

3. While exceedingly minute quantities of copper in solution are toxic to certain unicellular organisms, as bacteria, it is safe to assume that the higher plants and animals, including man, are unaffected by solutions containing the same or even larger amounts of copper.

4. There being a number of factors which tend to eliminate copper from its solutions, it is hardly likely that there would be any copper in solution by the time the water from a reservior reached the consumer if the treatment of the reservoir were in competent hands.

5. Many plants contain relatively large quantities of copper, and when these are used as food some of the copper is taken up by the animal organism, but there are no records of any ill effects from copper so consumed.—*Scientific Amer. Supl.*

LOST ARTS.

Not as much as we used to, but occasionally even yet, one hears of some wonder accomplished by the ancients which cannot be done now.

Not so many years ago it was quite commonly asserted that modern workmen could not quarry, or, having quarried, could not handle stones as large as the monoliths of Egypt; and the writer has heard a public speaker of note assert that it would be impossible to handle, with modern implements, such large stones as were used in the pyramids, or to join them as perfectly as they were joined there; yet, when occasion arose, larger stones than any of these were quarried in Maine, and some of the larger monoliths themselves were transported, not only to the sea, but across it, and erected in England, France, and America; and there are individuals to-day who might, if they chose, cause the transportation of and erection in this coun-

try of the largest pyramids, or build new ones ten times larger and more durable. Pyramids are not being generally built, nowadays, because they are not in line with the trend of modern ambition; that's all.

It is very doubtful if a "Damascus blade" would stand half as severe usage as a modern band-saw blade, or even as much as the spring of a forty-cent clock; while the ornamentation of those wondrous blades, so far as the mechanical execution is concerned, can be excelled by apprentices and amateurs of to-day.

Of the "lost art" of hardening copper little is heard of late years, though one occasionally hears a wiseling from the wilds wish that he knew how to do it as well as the ancients; and, while it is perhaps regretable that he doesn't, his ignorance is his own fault.

Many arts and devices have been abandoned because new knowledge has made them useless, and time spent in rediscovering them would be worse than wasted. The modern youth would much better spend his time studying the art of his contemporaries than that which is "lost."—*Scientific American.*

ARTIFICIAL CORUNDUM WITH ELECTRIC FURNACE.

In the high temperature produced in the electric furnace it has been shown that all substances can be melted. The oft-encountered statement that lime, magnesia, molydenum, tungsten, and the like, are infusible is therefore incorrect, for not only can all known substances be melted, but they can be volatilized as well. These facts are full of significance and suggestion to the engineer. They not only show him that there are limitations upon the materials which he may use for furnace construction, introducing difficulties where the highest temperatures are to be developed, but it is possible that in the melting and fusion of materials they may undergo such transformation of their physical nature as to endow them with qualities of great value. One of the most successful industrial uses of the electric furnace is the fusion of aluminum oxide in the form of bauxite, resulting in the production of that physical form of the material designated by the trade name "alundum." This is a duplication of nature's process for producing corundum, but the artificial product has marked advantages over the natural material in the purity, cheapness, strength, and toughness, which give it greater value for abrasive purposes.—*Electrical World.*

ENERGY EXPENDITURE IN PRODUCING LIGHT.

In his recent series of lectures on "Flame," at the Royal Institute, Sir James Dewar illustrated in a striking form the large amount of energy expended in the production of a small amount of light. The following figures show how inefficient the various lighting devices now employed are from a scientific point of view: Candle—Percentage of light, 2; non-luminous energy, 98. Oil—Percentage of light, 2; non-luminous energy, 98. Coal gas—Percentage of light, 2; non-luminous energy, 98. Incandescent lamp—Percentage of light, 3; non-luminous energy, 97. Arc lamp—Percentage of light, 10; non-luminous energy, 90. Magnesium lamp—Percentage of light, 15; non-luminous energy, 85. Cuban firefly—Percentage of light, 99; non-luminous energy, 1.

LIST OF DEEP BORINGS IN THE UNITED STATES.

A valuable reference work for the driller is a recent publication of the United States Geological Survey, which is entitled "A Preliminary List of Deep Borings in the United States," compiled by Mr. N. H. Darton, chief of the Western Section of Hydrology.

The first preliminary list of deep borings in the United States was issued as water-supply papers Nos. 57 and 61. The present publication includes all of the wells listed in these two papers, together with many additional borings, mostly of recent date. Messrs. M. L. Fuller and A. C. Veatch of the Eastern Section of Hydrology, and other geologists of the Survey, have contributed many new data. Descriptions of borings published in reports issued since 1901 have been incorporated as far as practicable. All the entries are by States and countries.

The wells and borings reported in the paper are all more than 400 feet in depth. The information concerning them has been obtained partly from replies to circular letters sent to all parts of the United States and partly from geological reports and other published sources. Owing to the difficulty of obtaining replies to the circulars, to lack of knowledge on the part of correspondents, and to the incompleteness of published records, doubtless there are borings which have not been reported. In regions of oil and gas wells, where borings are numerous, all the individual wells can not be listed, but representative wells are given. References to logs or records of the wells or extended descriptions of them are given in footnotes and following the list of wells in each State is a list of the principal publications relating to deep borings in that State.

This publication is listed as Water-Supply and Irrigation Paper No. 149. It may be obtained, free of charge, on application to the Director of the United States Geological Survey, Washington, D. C.

SUPPRESSING THE SMOKE.

One suburb of Cleveland containing large steel works has been redeemed in the most remarkable manner by the introduction of automatic stokers, so that there is now a place for human beings to live, where formerly all was soot and blackness. The president of a manufacturing company using four stokers reports that he is not only paying from fifty to seventy-five cents less per ton for his fuel, but is burning six tons less per day than formerly, and at the same time getting better satisfaction in the maintaining of a uniform steam pressure. It is undoubtedly true that the agents of smoke-abating devices of all sorts have been extravagant in their claims and that they have damaged their own business by such claims, but this is a mistake not confined to the furnace business. A conservative claim of from 10 to 20 per cent saving, depending upon how smoky the furnace has been, can usually be substantiated by a comparison of the coal bills before and after introducing stokers, without resorting to expert tests.—*Scientific American Supplement.*

ELECTRIC LOCOMOTIVES.

The New York Central Railroad has made a lengthy series of tests of an experimental electric locomotive, designed for handling the express traffic within a radius of 35 miles of the New York treminal station. These tests have been carried out on a six-mile stretch of track on the main line of the company's system, west of Schenectady, and they have now been continued steadily for such a long period of time, that the engine may be said to have experienced practically every conceivable condition of weather, load, and track. The data gathered in this way are so eminently satisfactory, that the company has placed orders for electrical equipments, which are said to aggregate over $6,000,000 in value. The order includes thirty-five electric locomotives for the through express service, and 175 cars, which are to be used in the suburban service. Each of these engines will weigh about ninety-five tons and will develop normally 2,200 horse-power, although this amount can be exceeded when it is necessary. They will be carried on eight 44-inch driving wheels, all coupled. Although the draw-bar pull considerably exceeds that of the most powerful steam express locomotives of the day, the concentrated load on the drivers will be considerably less than that on steam locomotives Each engine will be able to haul at schedule speed a train of about twelve cars, equivalent to a load of about 500 tons. The electric locomotives will be coupled to the main-line incoming texpress trains at Croton, where there will be a running shed and shop conveniences for both the steam and electric locomotives. The expresses will be run into and brought out from New York City entirely by electric power. The same conditions will prevail at White Plains, twenty-five miles out from New York City on the Harlem Division, where the steam locomotives will be uncoupled and the electric locomotives will take their place. It is expected that this equipment will be ready for work within the next twelve months, by which time sufficient progress will have been made with the change of tracks to admit of a partial use of the electrical service.—*Scientific American.*

RADIUM AND SPONTANEOUS GENERATION.

A special cable dispatch of June 24 to the New York *Evening Post* says: "The greatest interest has been excited by the discovery of Prof. John B. Burke, of the Cavendish laboratory, which may be summarized thus: After years of negative experimentation on the phospherescence of cyanogen, which Pfluger declared to contain the element of life, Mr. Burke resolved to test it with radium, and placed it in the test tube with sterilized bouillon. After a couple of days cultures were obtained of atoms which subdivide on reaching a certain size. Placed upon fresh portions of sterilized bouillon, these growths continue to grow slightly, thus showing that the influence of the raduim is only initiatory. Prof. Simms Woodhead pronounced them neither bacteria nor crystals; but they present many appearances of vitality and seem to indicate the possibility of spontaneous generation. * * * * Leading men of science maintain an attitude of reserve as to the vitality of Professor Burke's radiobes."

WIRELESS TELEGRAPHY.

THE GOVERNMENT AND WIRELESS.—A recent special dispatch to the New York *Tribune* says: "The wireless experts of the Government are applying themselves with energy to the problem of getting rid of the influences which are destined to interfere with that form of communication in time of war, or at least to prevent secret exchange of messages. There have been many assurances that this would be possible by means of special devices used, but it is found that the wireless stations along the coast obtain many messages, in whole or part, which are not intended for them. Thus, at the Washington Navy Yard recently there were received messages evidently being exchanged between ships in distant Southern waters. There is nothing to account for this irregularity in the action of the messages; so much depends upon the wave influences. At the same time, it is realized that something must be done toward the regulation of the wireless communication. Much may be acomplished by governmental control, but this may not be possible, now that the wireless companies are fully organized and have sold stock to people who may feel that their interests would not be helped by legislation along the lines suggested by the special joint board of which Rear Admiral Evans was the senior member. There is also much to be obtained from an international discussion of the subject, but this appears to be out of the question during the war between Russia and Japan and until the British and Italian governments adjust their relations with the Marconi people."

STANDARDIZING ANALYSIS METHODS.

H. E. Diller, Secretary of the Metallurgical Section of the Association, made a report for the past year. The principal work undertaken was the standardizing of methods of analyzing cast iron. The committee has agreed on the method for determining silicon and had almost ready a method for determining total carbon. The committee's method for the determination of silicon in pig iron and cast iron as follows:

"Weigh 1 gram of sample, add 30 c. cm. nitric acid (1.13 specific gravity); then 5 c. cm. sulphuric acid (conc.) Evaporate on hot plate until all fumes are driven off. Take up in water and boil until all ferrous sulphate is dissolved. Filter on an ashless filer, with or without suction pump, using a cone. Wash once with hot water, once with hydrochloric acid, and three or four times with hot water. Ignite, weigh and evaporate with a few drops of sulphuric acid and 4 or 5 c. cm. of hydrofluoric acid. Ignite slowly and weigh. Multiply the difference in weight by 0.4702."

The committee presented this method as one that sacrificed shortness to insure accuracy, and that left little to the judgment of the chemist. While it was recognized that it is almost impossible to get chemists to use a standard method in their daily work, the one proposed would serve as a check method in case of dispute between laboratories or between buyer and seller.—*Foundrymen's Assoc'n.*

Book Notices.

PUBLICATIONS RECEIVED.

Bulletin of the University of Wisconsin, No. 121, College of Engineering. Course in Chemical Engineering, Madison, 1905. 19 pages, 12mo. (A new course which has recently been adopted by the university.)

Inauguration du Percement du Simplon. Exposition de Milan, 1906. Programme de la Section de la Prévoyance Internationale. 6 pages. 8vo.

Niles Electric Traveling Hoists and Trolleys. Niles-Bement-Pond Company, New York, 1905. 23 pages, illustrations, obl. 8vo.

The Trump Concrete Measuring and Mixing Machine. Booklet No. 5. Philadelphia Link-Belt Engineering Company, 1905. 29 pages, illustrations, 8vo.

The Trump Measuring and Mixing Machine for Sand-Brick and Artificial Stone Manufacture. Booklet No. 56. Philadelphia, The Link-Belt Engineering Company, 1905. 16 pages, illustrated, 8vo.

The Weather Forces of the Planetary Atmospheres, by C. Merti. Niden, Switzerland. Printed by E. Weber, 1905. 21 pages, illustrations, 8vo.

Missouri Bureau of Geology and Mines, E. R. Buckley, Ph. D., Director and State Geologist, Vol. 3, 2nd Series. The Geology of Moniteau County, by F. B. Van Horn, with an introduction by E. R. Buckley. Jefferson City, Hugh Stephens Printing Co. n.d. 104 pages, illustrations, plates, maps, 4to.

U. S. Geological Surveys, Charles D. Walcott, Director. Mineral products of the United States, calendar years 1895 to 1904. Sheet 24x31½ inches. Washington, August, 1905.

United States War Department. Annual Reports for the fiscal year ended June 30, 1904. Vols. 11, 12, 13. Report of the Philippine Commission, parts 1, 2, 3; vol. 14, Acts of the Philippine Commission (Nos. 950-1251, inclusive) and Public Resolutions, etc., from September 24, 1900, to August 31st, 1904. 4 vols., illustrations, plates, maps. 8vo. Washington, Government Printing Office, 1904-5.

Twenty-first Annual Report of the United States Civil Service Commission for the year ended June 30, 1904. January 4, 1905. Washington, Government Printing Office, 1905. 366 pages, 8vo.

Origin of Planets and Cause and Mode of Production of Terrene Phenomena. Geography of pleistocene earth, by J. I. Lengsfield. Vicksburg, Mississippi, 1897. 6 pages, plate, 8vo.

Explanation of Cause of Weight, by J. I. Langsfield. Vicksburg, Mississippi, 1905. 8 pages, plate, 8vo.

Procédé pour déterminer la pureté de l'huile de coprah. Par M. Ernst Milliau. 1905. 4 pages, 4to.

Manufacturing Chemists' Association of the United States. Standard Tables for Aqua Ammonia, Hydrochloric Acid, Nitric Acid and Sulphuric Acid. (Folded sheets.) New York, 1903 and 1904.

The Principal Professional Papers of Dr. J. A. L. Waddell, Civil Engineer. Edited by John Lyle Harrington, Civil Engineer. First Edition. Virgil H. Hewes, 245 West 107th Street, New York. 1905. (Price, $5.00, postpaid.)

The title leaves the reader under the impression that the book before us is the work of one author, whereas it is really the work of many, including a formidable array of the giants of the profession; for the editor has included much, if not all, of the discussion which followed the more important of the papers selected, and has himself given us, not only a preface and a biographical sketch of the author, but also notes introductory to most of the papers, and editorial comments following them.

The words "First Edition," in the title page, leave room for the inclusion of further papers in later editions; and that such papers are to be expected may be inferred from the author's portrait, which forms the frontispiece, and which, like the biographical sketch, shows him to be a man with decades of good work ahead of him.

Most of the papers here printed have long been well known to the profession; but the editor, having found them exceedingly helpful to him, has here collated them in convenient form.

Except the first two papers, "Railroad Drainage" and "Notes on Railroading," which appeared in 1878 and 1879, respectively, the papers here collated were written during the score of years from 1885 to 1904, inclusive.

Among the subjects treated, three stand out pre-eminently, viz.: (1) the education of civil engineers, (2) the design and construction of bridges, and (3) elevated railways. These subjects, together, occupy more than eighty per cent. of the volume.

The author's views on the education of the civil engineer are embodied chiefly in two important papers, viz.: IV, Civil Engineering Education, published in Engineering News in 1886, and XXI, Higher Education for Civil Engineers, a paper read before the Engineering Society of the University of Nebraska, in 1904.

From the use of the hackneyed term, "higher education," it is not to be inferred that the author advocates what is so generally understood under that term, viz.: a high degree of superficial and chiefly ornamental finish; but, on the contrary, a broadening and deepening of the foundations of civil engineering education, with such increase in the dimensions of the superstructure as this strengthening of the foundations will warrant.

The principal papers on the design and construction of bridges are—

VIII. General Specifications for Highway Bridges of Iron and Steel, a paper read before the Engineers' Club of Kansas City, in 1888, and published in the Transactions of the Association of Engineering Societies, Vol. VII, No. 11, November, 1888.

IX. Some Disputed Points in Railway Bridge Designing, Transactions American Society of Civil Engineers, Vol. XXVI, February and March, 1892.

X. The Compromise Standard System of Live Loads for Railway Bridges and the equivalents for same, 1893.

In the general specifications for highway bridges, the author paid his respects to highway bridge builders (whom he dubbed "highwaymen,") and

expressed a doubt as to "whether it be possible to reach county commissioners and produce any impression upon them."

A lively discussion was brought out by the other two papers named, and notably by their dominant feature, viz.: the plea for the abandonment of the use of concentrated wheel loads in the determination of stresses, and the substitution, for them, of an equivalent uniform load.

A glance over recent bridge specifications, both by bridge builders and by railroad companies, bears out the editor's statement on page 458 "that the wheel load method of computing stresses in railway bridges remains in very general use to-day," a fact which the editor deplores as "not at all complimentary to the railway and the bridge engineers of the country," and as attributable "chiefly to their failure to understand the degree of accuracy obtainable by the Equivalent Uniform Load Method."

The discussion brought out considerable difference of opinion as to the amount of labor involved in the determination of stresses by means of concentrated wheel loads, and, consequently, as to the desirability of replacing that method by a simpler one.

In papers XIII and XX, the author describes respectively his well-known and unique Halstead Street lift bridge at Chicago, and his emergency work in replacing a span of the Kansas City Flow Line bridge, carried away by a flood in 1893. This mishap cut off the city's water supply and thus placed the city in "constant and imminent danger from fire and pestilence."

Paper XIV, Elevated Railroads, with the discussion which follows it, may be regarded as a well-illustrated treatise of nearly 200 pages, by authors foremost in this branch of the profession.

The author, as consulting engineer to the Northwestern and Lake Street Elevated Railroads, Chicago, made "an elaborate investigation concerning the best way to design, manufacture and build such structures;" and his paper discusses in detail the materials to be employed, the dimensions and weights of rolling stock, the most advantageous length of span, the use of braced towers *versus* solitary columns, the anchorage of columns, the use of plate girders or of trusses, forms of rails, bracing and superelevation on curves, etc., etc., and submits, describes and illustrates thirteen distinct designs for such structures.

The editor's bioraphical sketch of the author easily explains the preponderance, already noted, of engineering education and of bridge design and construction, in the papers here presented; the author having acted as assistant professor of two branches in the Rensselaer Polytechnic Institute, and from 1882-86 as Professor of Civil Engineering in the Imperial University of Tokio; while, since that time, his professional activity has been very largely in the field of bridge engineering.

The author's deep interest in matters Japanese is shown in paper III, an address delivered before the members of the Kogoku Kyokai, in 1886, at which early day he felt called upon to criticise rather unsparingly the condition of many of the engineering features of the country, and even remarked that, at that time, "well-filled bookshelves" would have formed an innovation in the furnishing of their homes. Still worse, we learn, from both

author and editor, that "Japan's business methods and her ideas of business integrity are still quite oriental, to her detriment." Judging from recent expressions by the author, the writer is led to suppose that the Asiatic Ethiopians, under consideration, may, to some extent, have since changed the skins which they wore twenty years ago.

The author's writings have ever betrayed, by their virility, his inheritance of the proverbial combativeness of his Hibernian paternal ancestors. Hence it is not surprising to find even some of the earlier papers so far in advance of their time as to be well up-to-date to-day, even though some of them may now be found abreast of (rather than in line with) our present notions. In those few cases where the procession has moved on beyond them, the editor's comments will be found to make up, in great part, for the deficiency.

The "papers" constitute a good story, well told, and they leave the profession indebted both to the author and to editor. J. C. T., Jr.

Hypochlorite und elektrische Bleiche. Theoretischer Theil. Theorie der elektrochnische Darstellung von Bleichlauge. Von Dr. Emil Abel. Chemiker der Siemens & Halske A.-G. Wien. Mit 10 Figuren und 10 Tabellen im Text. Halle a S. Verlag von Wilhelm Knapp. 1905. (Price, 4.50 marks.)

This volume forms the seventeenth of the invaluable series of monographs upon applied electricity issued from the Knapp press. Like its predecessors, it is a thoroughly well presented exposition of the art to which it relates. W.

Select Methods in Food Analysis. By Henry Leffmann, A. M., M. D., and Wm. Beam, A. M., M. D., F. I. C. (Second edition, revised and enlarged, with one plate and fifty-four other illustrations. 8 vo. pp. vi + 396.) Philada.: P. Blakiston's Son & Co. 1905. (Price, $2.50 net.)

This second edition of a work that has met with the cordial approbation of analysts in this field, exhibits many additions which serve to make it an up-to-date hand-book. The principal additions relate to polarimetry, destillation and extractions; new processes for the detection of colors, such as substitutes for fruit and egg colors; improvements in the detection of formaldehyde, abrastol and saccharin; rapid methods for the examination of vanilla and lemon extracts, and for the determination of fat in condensed milk and cereal foods; determination of boric acid in fruit juices; analytic data regarding fruit juices, jams and jellies; detection of palm oil in oleomargarin, and numerous minor modifications of tests and processes. W.

Practical Laws and Data on the Condensation of Steam in Covered and Bare Pipes, to which is added a translation of Péclet's "Theory and Experiments on the Transmission of Heat Through Insulating Materials." By Charles P. Paulding, M. E. 8-vo. pp 102. New York: D. Van Norhand Co. 1904. (Price, $2.00 net.)

The author sets forth in this volume the application of Péclet's method to the estimation of the loss of heat from steam pipes and boilers. The accompanying translation of Peclet's work will be welcomed by heating and refrigerating engineers. W.

Sections.

(*Abstracts of Stated Meetings.*)

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—The thirty-fourth stated meeting of the Section was held Thursday, October 26th, 8 P. M. Dr. Henry Leffmann in the chair.

Present, 39 members and visitors.

Mr. C. C. Balderson presented the first communication of the evening—a description of and demonstration with a new form of reflecting lantern, devised by Messrs. Williams, Brown & Earle, of Philadelphia. The speaker showed the possibilities of the apparatus by projecting on a screen a number of illustrations from books and other opaque objects. The subject was discussed by Drs. Leffmann and Goldsmith and the speaker.

Dr. Henry Leffmann followed with a paper entitled, "The Need of Legal Restrictions on the Publication of Photographs."

The speaker referred especially to the abuses now so evident in connection with postal cards and moving-picture shows, and urged the need of legislation to prevent the undesired publication of portraits of private persons. The meeting then adjourned.

M. I. WILBERT, *Secretary.*

CHEMICAL SECTION.—Stated meeting, held Thursday, November 9, 8. P. M. Dr. R. H. Bradbury in the chair.

Present, seventeen members and visitors.

The President introduced Dr. Edward Keller, of Baltimore, Md., who presented a paper on New Laboratory Appliances.

The subject was discussed by Dr. Edward Goldsmith, Dr. W. J. Williams, Dr. R. H. Bradbury and Mr. C. J. Reed.

The thanks of the Section were voted to the speaker of the evening and the session was adjourned.

EDWARD A. PARTRIDGE, *Secretary.*

Franklin Institute.

(*Proceedings of the Stated Meeting held Wednesday, November 15, 1905.*)

HALL OF THE INSTITUTE,
PHILADELPHIA, November 15, 1905.

PRESIDENT JOHN BIRKINBINE in the chair.

Present sixty-three members.

Additions to membership since last report, three.

The Chairman introduced Mr. John C. Trautwine, Jr., member of the Institute, who read an interesting paper on The First Water-works of Philadelphia. The speaker's address was profusely illustrated with the aid of lantern pictures showing many of the engineering details of this now historic plant.

After some discussion of the subject, the meeting passed a vote of thanks to the speakers of the evening and was adjourned.

WM. H. WAHL, *Secretary.*

Committee on Science and the Arts.

(Abstract of Proceedings of the Stated Meeting held Wednesday, November 1, 1905.)

DR. EDWARD GOLDSMITH in the chair.

The following reports were adopted:

(No. 2322.) *Pressed-Steel Shaft Hangers.* The Standard Pressed Steel Co., Philadelphia.

ABSTRACT: These hangers are made from sheet steel pressed into shape and the parts riveted together, making a hanger which is much lighter and stronger than hangers made from cast-iron.

Excepting the box, bolts, rivets and adjusting screws, the hangers are made entirely from the best open-hearth steel, pressed to shape.

The legs, their entire length, are strongly ribbed and flanged. These legs are securely tied together at three points: at the feet, by a corrugated steel tie-plate; in the middle by a strongly corrugated and riveted brace; and at the extreme ends, by a pressed steel yoke, which caps them, removing the last chance of their spreading.

The yoke is held in place by two bolts, which fit accurately in drilled holes. As these run through the legs, not into them, it is obvious that the force applied cannot strip the thread or make the bolts come loose. Thus, the frame is very rigid, is well able to carry the load for which it is intended, and yet weighs only one-half as much as any other shaft-hanger of the same size.

Instead of having to remove the yoke from the hanger when the shaft or box is to be fitted, it only requires the removal of one of the bolts, when the other acts as the part of a hinge, and allows the cap to swing out of the way. When the box has been placed in position it is but a moment's work to swing the yoke back, insert the bolt, and the hanger is ready for use.

Another advantage is the fact that the feet of the hanger are pressed to shape in dies and are therefore absolutely true. This assures a secure base for the hanger, a firm hold upon the joist, and removes the least chance of its shifting out of position.

The report of the Committee calls attention to the fact that these products represent another profitable use to which pressed steel may be applied. The award of the John Scott Legacy Premium and Medal is recommended to the inventor, Mr. Howard P. Hallowell. (*Sub-Committee*, Anson W. Allen, Chairman; Robert Job, Chas. Day, Thomas P. Conard.)

(No. 2368.) *System of Flame Regulation.* Byron E. Eldred, Brookline, Mass.

ABSTRACT: This invention consists of a method of regulating the temperature, volume and duration of flames produced in the combustion of fuel, and the application of this method to various industrial processes,

such as the calcining of lime and cement-forming material, the roasting of sulphide ores, etc.

The essential feature of this invention is the use on an "artificial accellerated draft, composed of air and a neutral gaseous diluent," in place of the current of ordinary air with which it is customary to supply fires. The diluent consists of gases like nitrogen and carbonic acid, which are neither combustible nor supporters of combustion, and which may be derived from the combustion of fuel or the burning of lime rock.

By adding a suitable proportion of this diluent—say one volume to three or four volumes of air—and then forcing the mixture by a suitable means, such as a fan-blower, through the fire, a practically perfect combustion of the fuel is obtained, while the liberation of the heat is so retarded as to furnish a flame of great length and volume. In this way, the overheating of those parts of the furnace and the charge which are near the fuel is prevented, and the heat is liberated where it is needed. The principal application of this idea is in the calcining of lime and cement-forming material. This is covered by U. S. Letters-patent No. 692,257 February 4, 1902.

In the burning of lime by the continuous process with external fires, wood, or a mixture of wood and soft coal is generally used as the fuel. In the process as modified by Eldred, coal, even of very inferior grade, may be used instead. It is claimed that the flame in this case can be so regulated as to insure a very uniform burning of the rock and the prevention of overburning any part of it.

* * * The actual heat of the combustion of fuel cannot be increased by the introduction of a neutral diluent, the effect of the latter being simply to distribute the heat of the combustion over a larger space, permitting a better utilization of the heat, and the effective use of inferior grades of fuel.

Recognizing that the Eldred method has proved itself satisfactory and economical in its application to lime-burning, and believing that it will be applied advantageously in other directions, the award of the John Scott Legacy Premium and Medal is recommended to the inventor. (*Sub-Committee*, Harry F. Keller, Chairman; Chas. E. Ronaldson, Thos. P. Conard, G. H. Clamer.)

The following report passed first reading:

(No. 2372.) *Physical Diagnostic and Surgical Instruments.* Henry Emerson Wetherill, Philadelphia.

Mr. Louis E. Levy, chairman of a special committee appointed for the purpose, presented a memoir of the late John Carbutt, which was accepted and ordered referred to the Committee on Publications.

WM. H. WAHL, *Secretary.*

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Vol. CLX, No. 6 *80th YEAR* *DECEMBER, 1905*

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COMMITTEE ON SCIENCE AND THE ARTS, First Wednesday of each month, 8 P. M. (except July and August).

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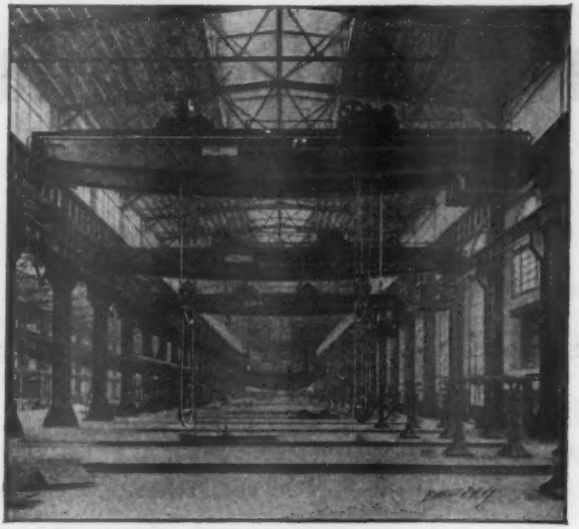

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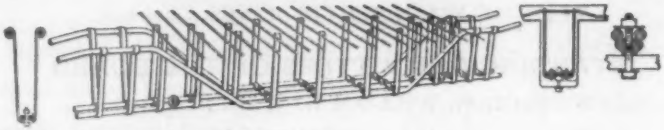

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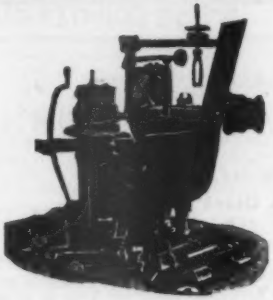

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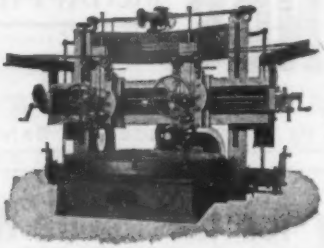

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4. Every memoir shall be anonymous, but shall containsome motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with some motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the FRANKLIN INSTITUTE to keep these envelopes securely and unopened until the Judges shall have finished their examination; when, should the Judges be of opinion that any one of the memoirs is worthy of the Premium, the corresponding envelope shall be opened, and the name of the author communicated to the INSTITUTE. The sealed envelopes accompanying unsuccessful memoirs, will be destroyed unopened, in the presence of the Board of Managers.

5. Should the Judges think proper, they may require the experiments described in any of the memoirs to be repeated in their presence.

6. The memoirs presented for the Premium shall become the property of the FRANKLIN INSTITUTE, and shall be published as it may direct.

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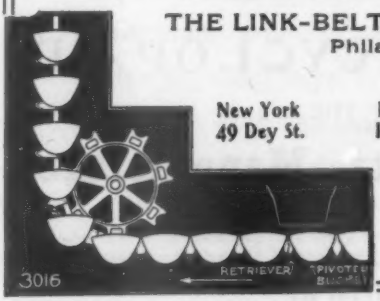

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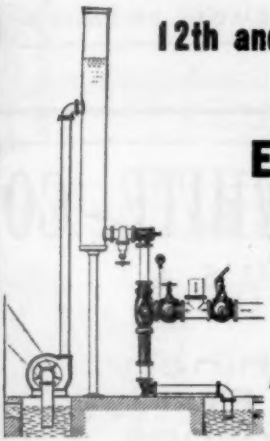

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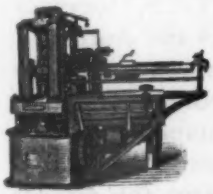

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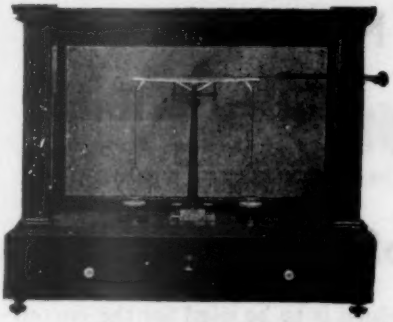

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